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Rochester Institute of Technology

A Research Monograph of the

Printing Industry Center at RIT

No. PICRM-2010-07

R·I·T Printing Industry Center
An Alfred P. Sloan Foundation Center

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Foreword

We all have experienced the move from print to screen with the advancement of digital technology. We see college-aged young adults use their laptop for many things that previously involved print. This gives rise to many questions, including: Which medium do these young adults prefer? Are information consumption and retention different based on the viewing medium? Does the medium preference change depending on whether people look at a magazine or at photographs that they took?

When discussing the Printing Industry Center research agenda for 2009 through 2010, the authors decided to create three related projects aimed at taking the first steps toward identifying and understanding the differences in how information is consumed from print on paper versus computer display. Each project would encompass experimentation and some form of interview with the participants.

Part I: An Experimental Study of Presentation Medium–Dependent Differences of Picture Consumption by College-Aged Adults, conducted by Franziska Frey and Mariela Rodriguez Adames, focused on starting to understand the viewing preferences, printing behavior and content management behavior when the observers were looking at their own photographs.

Part II: An Experimental Study of Differences in Reading Photo Books by Presentation Media: Print versus Screen, conducted by Ya-fang Tsai and Frank Cost, and *Part III: What are You Looking at? Evaluating Observer Eye Movements as They Look at Images in Print and on Computer Screens*, conducted by Susan Farnand, both dealt with various aspects of participants looking at a magazine-style publication that was heavy on image content.

Since the research questions guiding the three projects were so interconnected, the decision was made to publish the three studies together in one monograph. While some questions were answered, new ones arose during the course of the research projects. A summary of the results and ideas for future research for all three studies can be found in the executive summary. The research background, methodology, and detailed results for each of the experiments can be found in Parts I, II, and III of this monograph.

Executive Summary

Part I

An interesting future lies ahead for the consumer photographer. The use of digital technologies has forever changed how consumers are taking, sharing, and keeping their pictures. The dominance of a few market leaders in the conventional photographic consumer market has vanished. In the digital photography market, many new players are addressing parts of the value chain. As a result, the consumer is left with too many choices. For the photofinishing industry, these choices are major and very difficult changes to deal with. Companies wanting to make money by selling either printed or digital products of digital images to consumer photographers need to understand how the change to digital photography has impacted the practices of consumer photographers. Understanding the printing behavior, presentation medium-dependent differences of picture consumption, and content management behavior of consumer photographers are the first steps in that direction. What will ultimately matter to consumers is whether the new technologies will allow them to more easily keep their memories for a lifetime.

The objective of Part I of this study was to obtain an overall picture of the current state of consumer photographers' practices when it comes to taking, sharing, and keeping pictures. Experiments conducted on the presentation medium-dependent differences in picture consumption of the observers' personal images showed that a majority of the participants preferred printed images to images viewed on a screen. Regardless of this preference, participants did not print images very often for a variety of reasons, including lack of time or money. In addition, results showed that the most commonly used printing tools included Kodak EasyShare Gallery, Shutterfly, and Flickr. Finally, participants cited Photoshop, Lightroom, and Picasa as the primary editing tools, with Facebook being mentioned as the main sharing tool.

Ideas for future research include the following: What incentives could companies offer to college-aged young adults to get them to print more? Companies wanting to make money from selling printed or digital products of college-aged young adults' digital images need to understand how content management can drive their business. Connected to this are questions around metadata: How can metadata contribute to a better semantic understanding of photos? Can a framework be developed for the intelligent fusion of content, context, and usage metadata which would enable the creation of high-quality and semantically-rich photo annotations? This analysis framework could be employed for the intelligent management of personal photos, such as the determination of a meaningful selection or the automatic authoring of personal photo albums.

Parts II and III

The advent of digital print engines capable of achieving high image quality has opened up many new and exciting print product opportunities, including the short-run printing of magazines. However, content available for magazines is also readily available online. The objective of this project was to take the first steps toward identifying and understanding the differences in how information is consumed from print on paper versus computer display and which characteristics of these media are particularly relevant in this comparison. This evaluation involved an assessment of differences for several metrics, including: information retention, time taken to view images, preferences for visually consuming information, and distribution of visual gaze as measured by eyetrackers. Experimentation was conducted that focused on the first three of these four factors, which is discussed in Part II of this monograph.

Experimentation conducted in Part III generally confirmed the results of the study in Part II; specifically, that people preferred the hard copy rendition over a PDF when given the choice (for reasons of image accessibility and tangibility), and that neither the time used to view the photo books nor information retention as measured by image recognition and information recall were affected by the medium in which the photo book was seen. The results of this study also agreed with earlier research findings that observers tend to fixate first and most often in the central areas of images. However, this research also found important differences between how the observers viewed the printed and screen versions of the photo book, with the screen group having more fixations per image for many of the images early in the book (although they did not spend more time with these images), while the print group switched more often between images. While the work conducted in Part II of this study suggested that there were no important differences between the print and screen groups of observers, the work in Part III hints at differences that may be important with regard to individual images or image layouts.

Longer-term, it is intended to explore how such differences affect the efficacy of magazine advertising. Further work involving image content having a more balanced mix of text and pictorial imagery might prove useful in exploring these findings further.

Part I: An Experimental Study of Presentation Medium–Dependent Differences of Picture Consumption by College-Aged Adults

by Franziska Frey, Ph.D., and Mariela Rodriguez Adames

Abstract

The use of digital technologies has forever changed how consumers are capturing, sharing, and storing their pictures. The long-term objective of Part I of this study is to obtain an overall picture of the current state of consumer photographers' practices.

While digital camera owners are taking more photos than ever before, most are not printing them. However, experiments conducted on the presentation medium-dependent differences in picture consumption showed that a majority of the participants prefer printed images to images viewed on a screen.

Regardless of this preference, participants did not print images very often for a variety of reasons, including lack of time or money. In addition, results showed that the most commonly used printing tools included Kodak EasyShare Gallery, Shutterfly, and Flickr. Finally, participants cited Photoshop, Lightroom, and Picasa as the primary editing tools, with Facebook being mentioned as the main sharing tool.

Introduction and Statement of the Problem

A study published by InfoTrends in 2004 revealed that, while most digital camera owners are taking more photos than ever before, most of them are not printing those photos. When they do, they only print in small quantities. Most users share their photos online or through e-mail. Moreover, there are some manufacturers who have a vested interest in increasing the number of digital photos printed. Thanks to pervasive Internet usage and other methods of sharing images, however, users simply do not feel the need to print photos (InfoTrends, 2004).

Miller (2007) states that "excluding a few ultra-heavy users, the average photo print volumes and expenditures for digital camera users are currently no higher than for film camera households. In addition, simple digital sharing through e-mail and other methods threatens to undermine the need for photo printing, unless vendors convince consumers prints are an archival method as well as a sharing vehicle" (p. 3).

On the other hand, content management is one of the new frontiers in consumer photography. While fewer people print their images at the moment they take them, the digital files that their photos create are saved for future use. How these images are used depends upon whether consumers can find and access them later on. Hence, this relies on the success of their content management strategy, as well as on the consumer's presentation medium preference. If companies want to monetize the digital assets of consumer photographers, then they need to understand how the consumer uses content management. A successful strategy for moving digital images into products—both printed and digital—involves a combination of the consumer's desire to save their memories with new, easy-to-use workflow solutions designed to create these products.

This research focused on understanding the content management and printing practices of consumer photographers. Within the scope of this project are changes for the consumer as a result of the shift towards digital photography, along with how they maximize the life of their photos (whether printed or stored digitally) and their preference in looking at printed versus on-screen images of photos. In addition, this research addressed user habits in picture taking, photo sharing, printing, and storing.

Background

Introduction

"A picture is worth a thousand words." With today's technology and the amount of pictures in existence, a picture is now worth a countless amount of words. Researchers have been working on finding a way to sort through pictures—along with any words linked to them—for over 20 years. Until recently, the majority of people wrote notes or captions on the back of pictures to classify and to manage them. With the advent of the digital age, and with digital cameras and photographs becoming the standard, physically writing captions on photographs is no longer possible. As an alternative, a number of ways for labeling digital photos have been proposed and implemented.

In his thesis, *Automation in Digital Photo Management*, Brady explains how, for digital photos, labeling may include renaming the picture file, placing a group of pictures in a labeled folder, or adding descriptors in photo management software. However, all of these are manual processes. In other words, they involve the person remembering information about the photo or deducing information by viewing it (Brady, 2007).

Currently, digital photograph management software has saved both home users and various professional users a great deal of time and money by helping the digital image annotation process states Grinter (2005) in her research *Words about Images: Coordinating Community in Amateur Photography*.

> "Researchers are working on automating many aspects of this process. Many of them focus on one aspect of improving digital photo management. However, with all of the

proposed or implemented solutions to the process, they need to be integrated in order to make an ideal system" (Grinter, 2005).

DAM Current Practices

In the past decade, the use of digital technologies in the consumer imaging experience —taking, sharing, and storing their pictures—has gone from a novelty for "techies" to the accepted norm for the masses. Images are easily captured with no need to worry about reloading film into the camera. Images can now be taken anywhere and anytime by anyone with a cellular phone camera. Sharing now takes many forms and is no longer limited to sending or handling prints of one's pictures. As consumers have adopted these new technologies and embraced new behaviors, there have been significant impacts on the retail photofinishing marketplace (Hitchens, 2009b).

In a study on how people organize their digital photos, it was noted that people usually upload all of their pictures chronologically from a memory stick (Rodden, 2003). In other words, the folders containing the pictures are labeled only by date. Any number of people, events, places, or time periods may exist in each folder. As a result, digital photo management becomes essential.

Automatic image annotation allows a person to take a picture, then upload it to a computer with software that automatically classifies the picture. This classification is based on the content of the picture instead of a user's description, which does not necessarily coincide with the actual content (Hitchens, 2009a).

Image Preservation

Long-term storage of images has changed over the past decade. Hard drives were the most popular storage method in both 1999 and 2006. Floppy disks, ZIP drives and Jaz drives were used in 1999, but are no longer a viable storage option today. The usage of CDs and memory cards has increased since 1999; DVDs, external hard drives, on-line storage, USB flash drives, and printed pictures were all mentioned as additional long-term storage methods for digital images in 2006 (LaBarca, 2007).

The Photofinishing Industry

The widespread acceptance of digital cameras by consumers has led to an explosion in the number of images captured each year, as has been well-documented. For the retail photofinishing market, this would seem to represent an opportunity for growth in photo printing. However, many of these digital images are not being printed. Instead, print volumes at retailers have declined. There are multiple reasons for this decline in printing at retailers:

- Images captured on film had to be printed to be viewed, whereas digital images can be viewed immediately on the camera screen or later on a computer screen. With the ability to preview digital images before printing, consumers can now print only the images they want.

- It is no longer necessary to print images to share them. Images can be shared by e-mailing them, uploading them to a photo website for online sharing, loading them onto a digital photo frame, or pulling them up on the display of a cell phone or digital camera.
- Consumers can choose to send their images to an online photo fulfillment website and have their pictures mailed to their homes.
- The print quality and speed of photo-enabled home printers have both improved significantly.

Within retail, digital technologies have caused a shift in consumer behavior as well. In the film-based imaging era, consumers dropped off their film, decided if they wanted single or double prints, and if they wanted prints in an hour or prints in a few days. As digital images became pervasive, consumers needed a new way to order their pictures. They were reluctant to drop their memory card into a photo mailer as they had with their film, and often did not want to print every image on the card. The solution was the photo kiosk (Devoy, LaBarca, & Rudak, 2009).

Photo kiosks had been present in the market for several years, but were primarily used by consumers to scan and reprint pictures from their collections at home. Photo kiosks were adapted to read the images from the consumer's digital media, help them compose their order, and select whether they wanted their prints in minutes, hours, or days. The convenience and speed of printing at the photo kiosk was now available for printing these digital images, shifting more print volume away from the on-site minilabs and off-site wholesale labs (Devoy et al., 2009).

Picture to Print Value Chain

Display Choices of Consumers

Many more manufacturers are offering services for displaying and storing images. Therefore, they are giving the consumer many more choices for viewing images than ever before. It is now more complicated and more expensive to address consumers, as a pre-defined starting point for displaying images no longer exists. In addition, consumer preferences are largely influenced by the equipment and/or methods that they use to display images. The industry is faced with a marketing dilemma, and the consumer is confronted with too many choices, as shown in Figure 1-1 (Fageth, 2009).

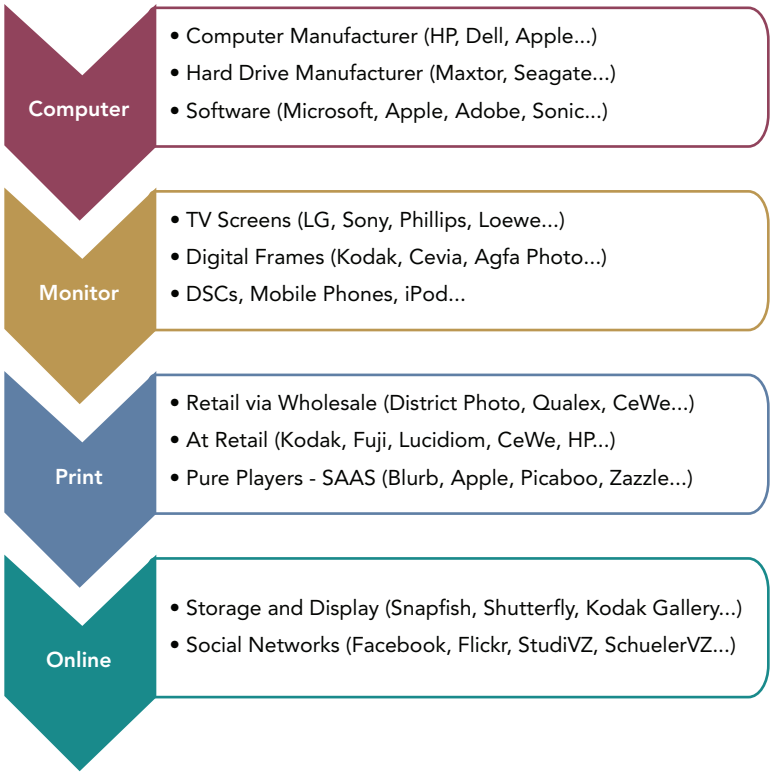

Figure 1-1. Consumers' image display preference choices

Consumers still have plenty of challenges to resolve on their own while working with digital images:

- Archiving the images using tools designed to assist with speedy retrieval once the images have been stored.
- Long-term storage of images.
- Selection of the most relevant/best images for archiving and display.
- Communicating and telling compelling stories with the stored images.
- Interaction among all of the hardware available (computers, online solutions, TV screens, digital frames, mobile devices, etc.).

There are several suppliers who offer solutions for one of the challenges mentioned above. There are very few who address two or more successfully. Market leaders' dominance in the former analog value chain (i.e., Kodak and Fuji) is gone; newer players are addressing specialized target groups. Looking at the display choices and the related variety of technologies, it is understandable why companies target specific consumer groups: There are too many different skills required to control all of the manufacturing challenges in digital display technologies in as competent a manner as, for example, Kodak did previously in analog photography (Fageth, 2009).

Opportunities for the Print Photofinishing Industry

Many of the new market opportunities are in photo products. In the early development stages of this category, the primary products were mugs and mouse pads. With the introduction of digital presses, greeting cards became the dominant product; this may still be true today in terms of units produced. However, photo books have emerged as a revenue driver. For the 3rd quarter of 2008, 54 percent of Shutterfly's $36 million in sales derived from personalized products and services (Franz, 2009).

A major contributing factor has been the evolution of photo book creation software. Only a short time ago, it was so complicated to create a photo book that studies revealed that 70 percent of all photo book orders started by customers were never completed (J. LaBarca, personal communication, September 3, 2009). Today it has become much simpler, even for consumers who do not have the time nor the inclination to get involved in the creation process. Now, software for Web or PC operation has the same "look and feel." This enables consumers to start creating a book at home, to take the file to a retail outlet and continue working with a friend or with assistance from store personnel, or to access the file on the Web from a remote location. The frustrations of not being able to complete the creation are being removed.

As consumers create their orders, kiosk software automatically up-sells to them using their own images. At the completion of a print order, the images are automatically assembled into a sample photo book which can be viewed on-screen, with photo book orders made into sample CDs/DVDs with music, etc. Many products, especially photo books, can be produced on site at photofinishing retailers.

Conclusion

An interesting future lies ahead for the consumer photographer. The use of digital technologies has forever changed how consumers are taking, sharing and keeping their pictures. The dominance of a few market leaders in the conventional photographic consumer market has vanished. In the digital photography market, many new players are addressing parts of the value chain. As a result, the consumer is left with too many choices. For the photofinishing industry, these are very difficult changes to deal with. What will ultimately count for consumers is whether the new technologies will allow them to more easily keep their memories for a lifetime.

Research Objectives

Companies who want to make money selling either printed or digital photo products to consumer photographers need to understand these consumers' printing behavior, presentation medium-dependent differences of picture consumption, and content management behavior.

The objective of this study was to obtain an overall picture of the state-of-the-art consumer photographer's practices, particularly of the taking, sharing, and saving of pictures by college-aged young adults. Specific research objectives and questions were:

- What are these young adults' printing behavior regarding their own images?
- What are the printing and media viewing preferences of college-aged young adults?
- What are their practices in terms of content management uses?

Methodology

Detailed Methodology

Groundwork of Presentation

A presentation was designed with 32 photographs (student pictures and reference pictures) in landscape and portrait formats. The amount of content in the presentation was adjusted to be viewable in less than 15 minutes. The prints were 4-inch by 6-inch, in both landscape and portrait formats. A 1024 by 768 pixel resolution 13-inch MacBook displayed the presentation digitally. The sizes of the pages displayed on the monitor were the same as the size of the printed pictures. The viewer was able to view the electronic version of the presentation page by page by using the "page up" and "page down" keys on the computer.

Choice of Subjects

All subjects participating in the experiment viewed both the printed pictures and the same images on the monitor. Subjects were drawn from two Digital Asset Management classes of undergraduate students in the College of Imaging Arts & Sciences (CIAS) at Rochester Institute of Technology (RIT).

The First Experiment

The experiment was conducted over a period of two weeks. Participants signed up for an hour-long session during the two-week period to participate in the experiment. Participants were advised not to talk about the experiment with their colleagues after taking the survey.

Participants were instructed to take as much time as they needed to review the content. A timer was started when the participant began, and the interviewer pressed the stop button on the timer when the participant finished. The times and observations were recorded, with participants identified by code only so that responses were not associated with specific individuals.

In a second part of the same experiment, participants reviewed a set of reference images: images they did not take, some new, and some shown earlier in the testing. They then identified the pictures as "previously seen on-screen" or "printed." If they did not recall the picture, they were asked to state that as well.

Interviews

After the experiment, observers were asked a series of questions (see Table 1-1) regarding their printing behavior when it comes to their photographs.

Table 1-1. Interview questions for the first experiment

Which pictures did you prefer: the printed ones or the ones on-screen? Why?
Do you ever print your pictures? Why?
If so, do you print them yourself or use a print shop or online service?
Do you know what type of paper/ink/printer you or the shop use?
Do your parents print?
What service/software or other online service do you use (like Kodak EasyShare, Snapfish, Flickr, etc?
Did you pay attention to pictures that were not yours? Why?
Do you want your pictures back? Why?
Would you like to participate in a focus group related to this research in the fall?

Once participants conducted the experiment, they were offered the printed copies of the photographs to keep. The choice that each participant made was recorded.

Data Analysis

An Excel spreadsheet related to the experiment was prepared. The spreadsheet contained one row of data for each coded participant. These included the times spent observing each type of media (print or electronic), the choice to keep the printed copies, and comments/observations made by the researcher.

The data analysis included participant background (gender, age, hearing status, and academic major at RIT), time spent observing each medium, willingness to keep copies or to buy them, purchasing price, and recall scores. Chi-square tests of association were run where appropriate.

The Second Experiment

A second experiment, based on the results of the first experiment described earlier, was developed and conducted, following the methodology described above. The topic of the questions accompanying this second experiment (listed in Table 1-2) focused on the content management behavior of the participants.

Table 1-2. Interview questions for the second experiment

Which pictures did you prefer: the printed ones or the ones on-screen? Why?
Do you take pictures regularly? If so, how many (approximately)? a. If yes, what type of camera are you using? b. What are your favorite subjects?
Do you ever print your pictures? Why? a. If so, do you print yourself or use a print shop or online service? b. Do you know what type of paper/ink/printer you or the shop use?
What format do you keep your pictures in? a. Digital file or print/both?
Do you keep your pictures? If yes (either digital or print): a. Please specify where – iPhoto, PhotoBucket, physical shoebox, etc.
Do you have backups of your pictures? If yes: a. What is your backup strategy? i. How often do you backup? ii. How do you backup? iii. Have you ever lost pictures that were not backed up? If yes, how often?
How do you organize your pictures? (i.e. name, file extension, size) a. Are you adding metadata? If yes: i. Are you using a particular metadata standard or standards? ii. How much time do you spend adding metadata to your pictures?
Do you go back and look at your pictures? If yes: a. How often? b. Can you find what you are looking for? If yes, why are you going back to your old pictures? i. To print them? ii. Use digital files in another format?
Do you share your pictures with your friends and family? If yes: a. In digital form or as a print? b. How do you share them (i.e., Flickr, Facebook, e-mail)?
What service/software or other online service do you use (Kodak EasyShare, Snapfish, Flickr, etc.)? For what specific use, e.g., sharing, printing, other?
Do your parents print? Do you know how your parents keep their pictures?
Do they add metadata? What is their backup strategy? Do they go back and look at old pictures? a. Can they find what they are looking for? b. Are they reprinting old pictures? c. Are they buying other photo products? (calendars, photo books, mugs, t-shirts)
Can we contact you with follow-up questions? Would you be interested to be part of a focus group around picture-taking practices?

Results

Results of the First Experiment

A summary of results from the first experiment, along with responses to the survey questions from 39 respondents, are detailed below. First, participant demographics are explored. Responses to questions related to image viewing, selection, and identification are discussed relative to the demographic findings where possible.

All participants (with the exception of the first five participants) were first shown digital images, then printed images. The experimentation combined both digital and printed images to clarify the suggestion that participants tend to spend more time while in the first mode in which they observe the images.

Participant Demographics

A total of 39 students enrolled in the spring 2009 Digital Asset Management class participated in the experiment. This group was composed of 38 percent females and 62 percent males. The ages of participating students ranged from 19 to 30 years old, with a median of 21 years old (as shown in Figure 1-2). More than 60 percent of respondents were between 19 and 21, with 23 percent were in the 22 to 24 range; this skewed the mean of 21.

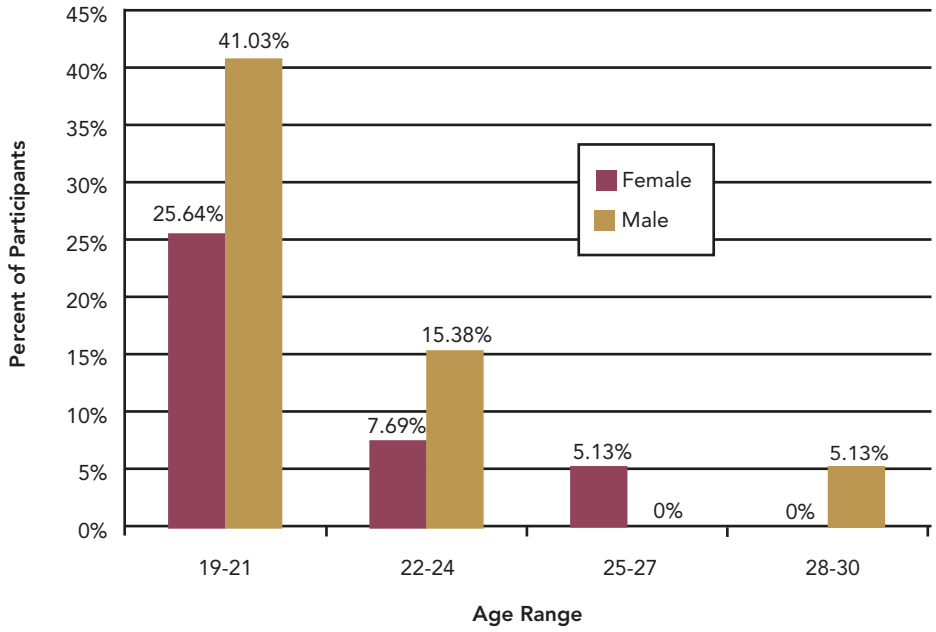

Figure 1-2. Percentage of participants by age range and gender

Figure 1-3 shows the distribution of students over five different programs in the sample. The programs are:

- Advertising Photography (JPHD)
- Graphic Media (JPRV)
- New Media Publishing (JPRW)
- Color Science Ph.D. program
- MBA program

Almost all of our respondents were in the New Media Publishing program (87%), followed by the Advertising Photography program (5%). There was no balance of the different programs over the age ranges, which might be an indicator of bias in the preferences.

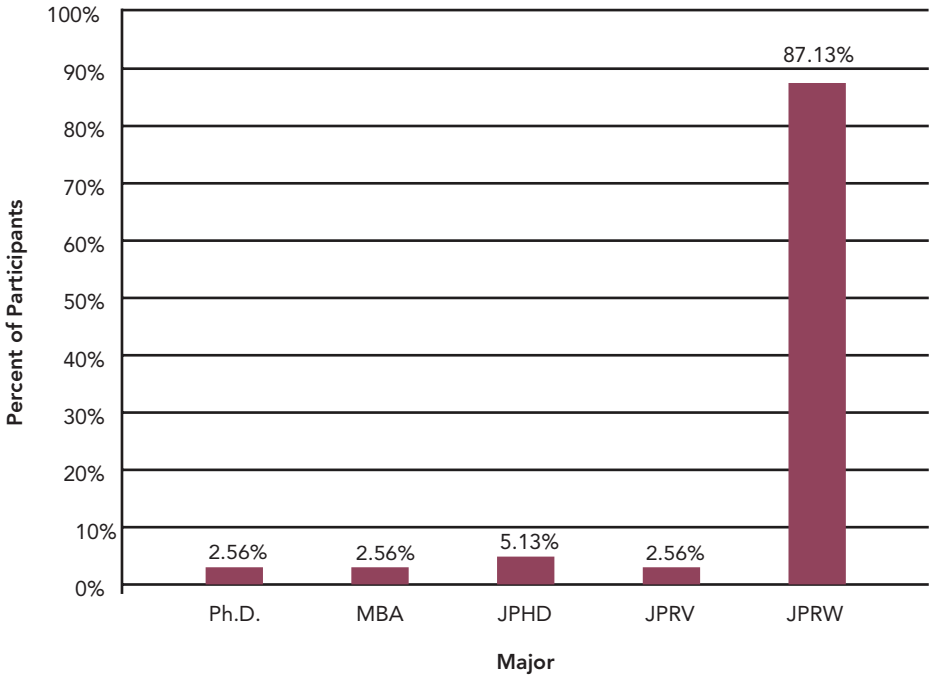

Figure 1-3. Percentage of participants by major

The participants were asked to carefully review the images, both on-screen and printed. The times spent reviewing the images were recorded, then analyzed by gender and age range. (See Tables 1-3 and 1-4 as well as Figure 1-4.) In general, when looking at the printed images, males spent approximately 23 percent more time than did females, while males and females spent essentially the same amount of time when looking at the images on-screen. The average time in the 19 to 21 age range was higher on-screen for females and higher on print for males. In the 22 to 24 age range, the average time spent on the printed images was higher for both males and females. For both male and female

participants more than 25 years old, the time spent was the same for images showed as prints and on-screen.

Table 1-3. Time spent looking at the printed images in seconds by gender

Gender	Average	Min	Max	StdDev
Female	130.67	59	251	56.44
Male	169.71	42	413	77.35

Table 1-4. Time spent looking at the images on-screen in seconds by gender

Gender	Average	Min	Max	StdDev
Female	150.80	47	296	57.97
Male	149.08	26	276	66.77

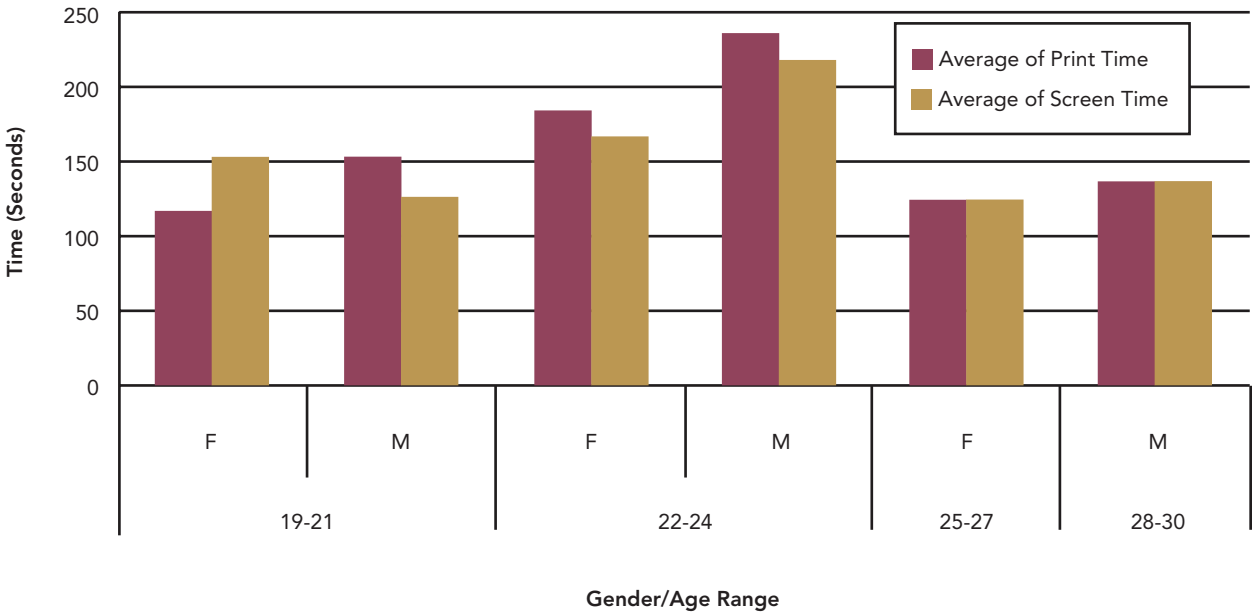

Figure 1-4. Average time spent looking at the images by presentation medium, gender, and age range

Statistical tests results show that the mean preference (print or screen) does not differ based on the time spent looking at the images in the different media, so it is likely that preferences are similar, whether or not the participant spent more time on print than on-screen or vice versa. (See Appendix A for the results of the chi-square tests.)

Viewing Preferences

Out of the pool of participants, 59 percent stated that they preferred to look at printed images, 38 percent preferred images on-screen, and 3 percent equally preferred both media. (See Figure 1-5.) Statistical study results suggest that the mean preference for print or screen does not differ depending on gender, so it is likely that both genders have similar preferences. (See Appendix A.)

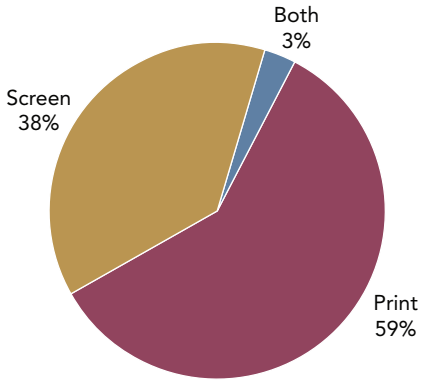

Figure 1-5. Distribution of image presentation preferences

Survey participants were asked to discuss why they preferred one presentation medium over the other, their likes and dislikes regarding their choice, and the issues and challenges with the alternative option. Responses are summarized below, with actual responses shown in Table B-1 (see Appendix B).

Almost 18 percent of the participants said that they preferred printed images because they could see more details in the images. Thirty percent preferred prints because they were easier to look through; they valued the opportunity to flip through them, to move them around, etc. Furthermore, the majority of participants (36%) liked the prints better due to their quality and their bright, shiny, and saturated colors.

Figure 1-6 shows the results when participants were asked whether they ever printed their images, regardless of their preference. Female participants ages 19 to 21 and 22 to 24 said that they never print in 70 percent and 67 percent of the cases, respectively. Forty-four percent of male participants in the 19 to 21 age range and 67 percent in the 22 to 24 age range also did not print.

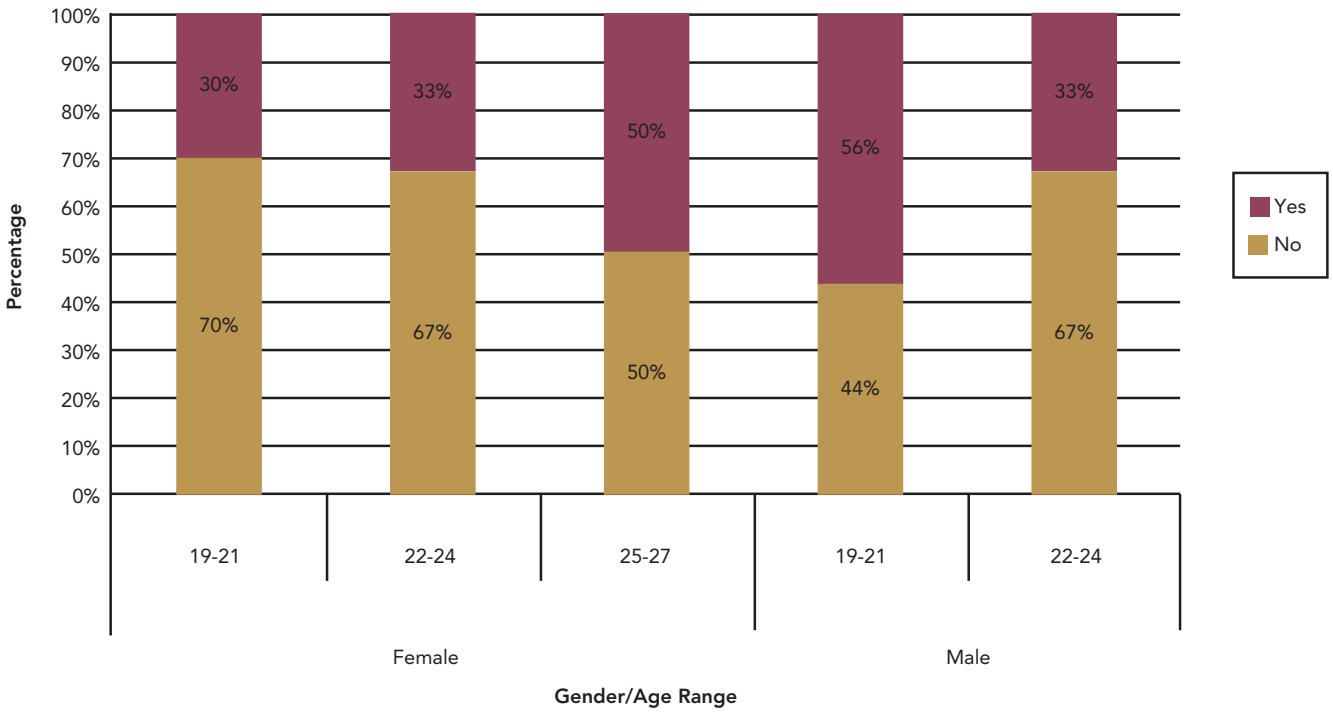

Figure 1-6. Percentage of participants who ever print by age and gender

The results show that 56 percent of the participants who print their pictures did spend more time looking at the printed images. On the other hand, 44 percent of the participants spent more time on the screen, even though they often print their images. Furthermore, the results show that 57 percent of the participants who never print their images spent more time looking at the pictures on-screen.

Table B-2 (see Appendix B) presents the reasons why participants may or may not prefer prints and why they do or do not print, along with their comments. Forty-one percent said that they do print their images. Among the top reasons for printing were to hang them up, to place them in a scrapbook, and to give them as presents. Fifty-nine percent of the participants said that they did not print, explaining as their main reason their lack of money to do so. Other reasons for not printing are mass media consumption (such as Internet media, blogs, message boards, podcasts, and video sharing) on computers, and having not much time to do so.

Figure 1-7 shows the percentage of participants who print by age range. Figure 1-8 shows the relationship between participants who print and whether their parents print. Forty-six percent of the participants in the 19 to 21 age range who print their images have 100 percent of their parents who also print. Participants in the 22 to 24 age range always print when their parents print, and when the participants do not print (67% of the cases), their parents print in 50 percent of the cases. For participants between 25 and 27 years old, their parents print 100 percent of the time, whether the participant prints (50%) or not (50%). For the last age range—28 to 30—even though the entire population does not print, 50 percent of the parents print.

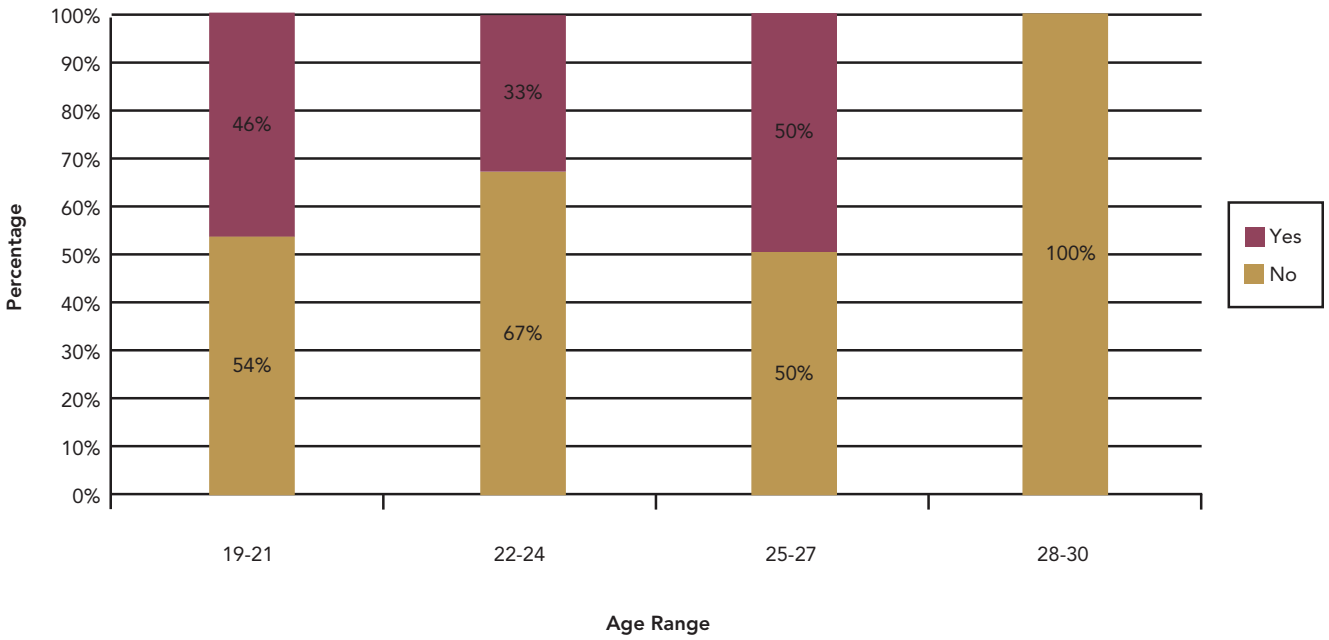

Figure 1-7. Percentage of participants who print by age range

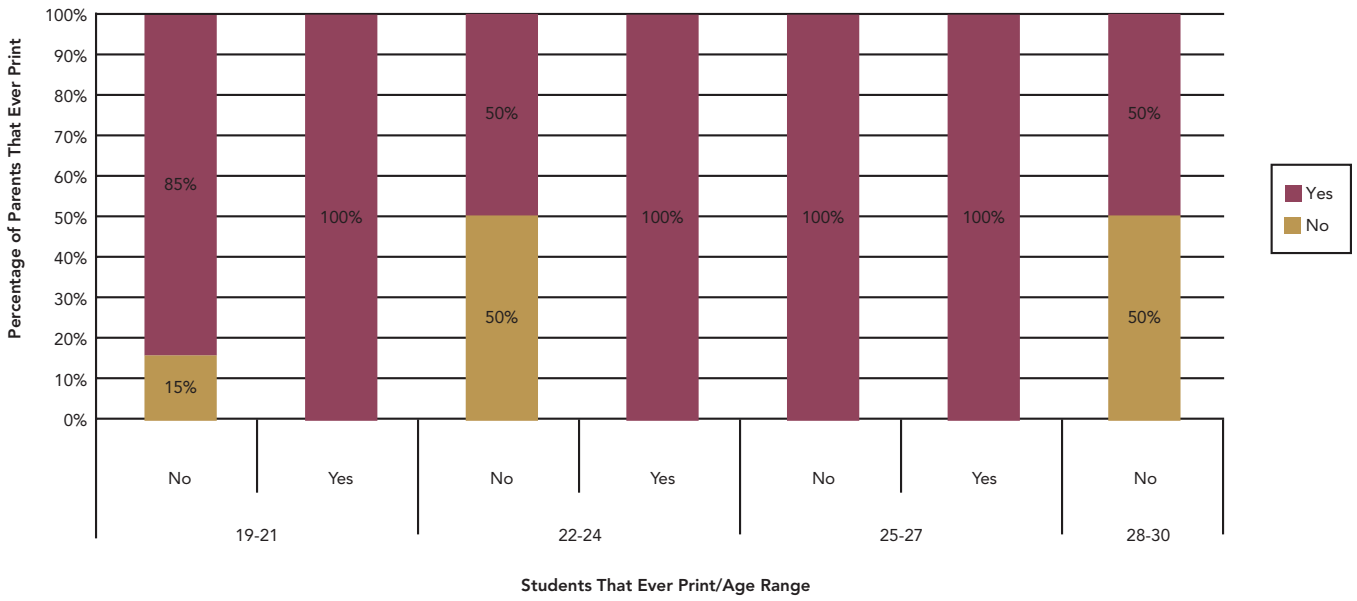

Figure 1-8. Percentage of parents who print by participant printing preference and age range

Participants of the study gave the responses shown in Table B-3 (see Appendix B) when asked whether or not their parents print their pictures and why. Eighty-three percent of the participants answered affirmatively when asked whether their parents print. Twenty-four percent of these parents usually printed at home using inkjet printers and regular paper. The remaining 76 percent sent their images to print shops such as Walgreens, CVS, or other pharmacies.

Printing Preferences

Figure 1-9 shows participants' preferences for printing their images, regardless of whether they currently print. Forty-one percent of participants do not have a preference for printing, while 31 percent prefer to print themselves and the remaining 28 percent say they would rather use a print shop.

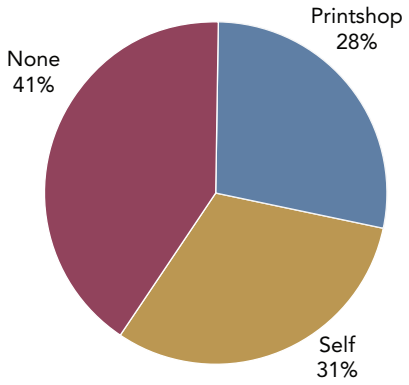

Figure 1-9. Participant preferences for printing

Figure 1-10 illustrates the percentage of participants who prefer to print at home by age range and gender. Sixty-seven percent of male participants 19 to 21 years old would rather print themselves than send pictures to a print shop, as would 33 percent of females. One hundred percent of male participants 22 to 24 years old prefer to print pictures themselves, while none of the females did.

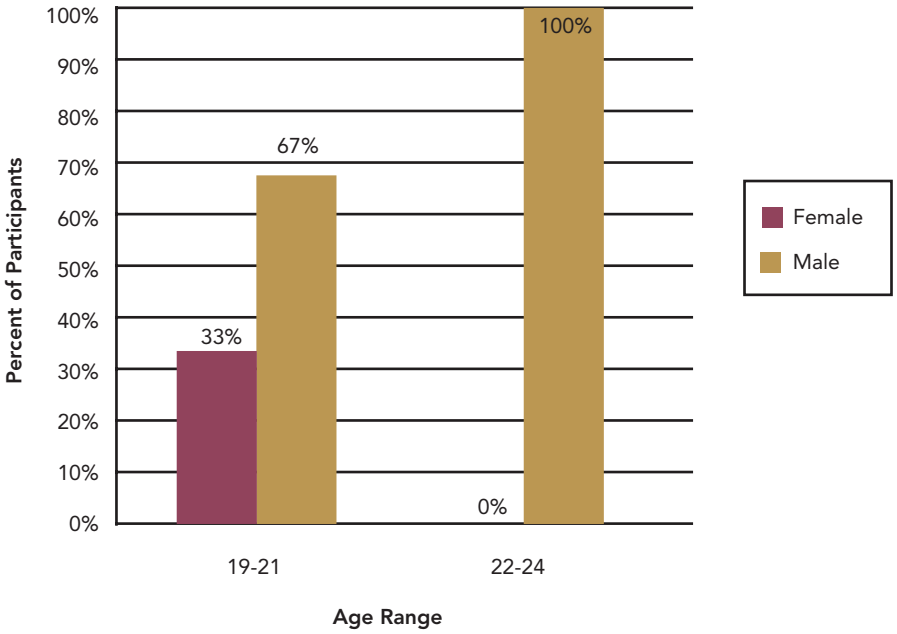

Figure 1-10. Percentage of participants who prefer to print at home by age range and gender

Participants were also asked whether they had a preference and/or whether they used a special type of paper, ink, and printer for printing purposes. None of the participants had a preference for paper type. In terms of ink, two participants specified HP, with one saying high-performance color photo ink must be used.

The printers named were:

- HP Photosmart
- Kodak
- HP DeskJet 5100
- Epson 2900
- LP 2500
- ISO Inkjet
- HP All-In-One scanner/copier/printer
- HPB9180
- Canon Pixma with Photo Ray Pearl
- Intel Professional
- Lexmark

Figure 1-11 shows the percentage of participants who prefer to use print shops or online services. Fifty-seven percent of the participants who preferred to use these services in the 19 to 21 age range were male, while 43 percent were female. Participants aged 22 to 27 who preferred print shops and online services were all female, while the participants in the age range of 28-30 were males who choose not to print themselves, but to use alternate options.

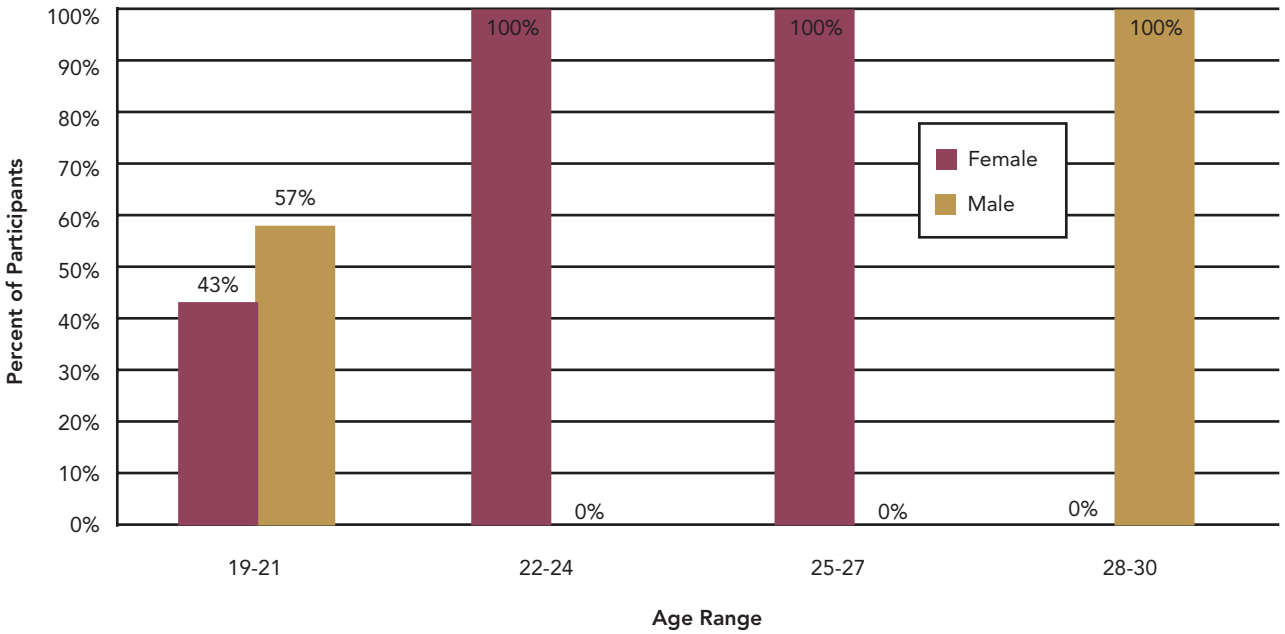

Figure 1-11. Percentage of participants who prefer print shops and online services by age range and gender

Research participants gave the responses shown in Table B-4 (see Appendix B) when asked about their printing options. When they did not print themselves, 32 percent of the participants used Flickr as a printing tool. Tiny Prints, Blurb, Moo, QOOP, and Image Kind were among other printing services. The rest of the participants used Kodak EasyShare Gallery and Shutterfly for printing. In addition, Photoshop, Lightroom, and Picasa were used as editing tools, with Facebook mentioned as the main sharing tool.

Image Identification

Figure 1-12 shows the participants' preferences when asked whether or not the images that the interviewers showed to them were shown previously in the experiment. Sixty-eight percent of the female participants and 80 percent of the male participants answered correctly.

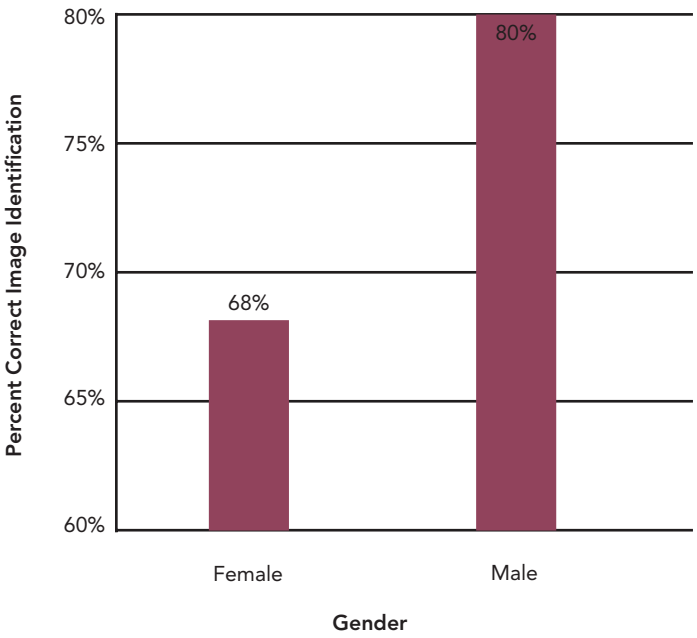

Figure 1-12. Percentage of images identified correctly by gender

Figure 1-13 illustrates the results of the exercise by presentation medium and gender. On average, 61 percent of the females correctly identified previously-seen images on-screen, while 39 percent correctly identified those previously seen in print. Forty-three percent of male participants correctly identified the previously-seen images on-screen, while 52 percent correctly identified those seen in print. These results may suggest that, in the young adults segment, females tend to prefer on-screen images while males tend to prefer prints.

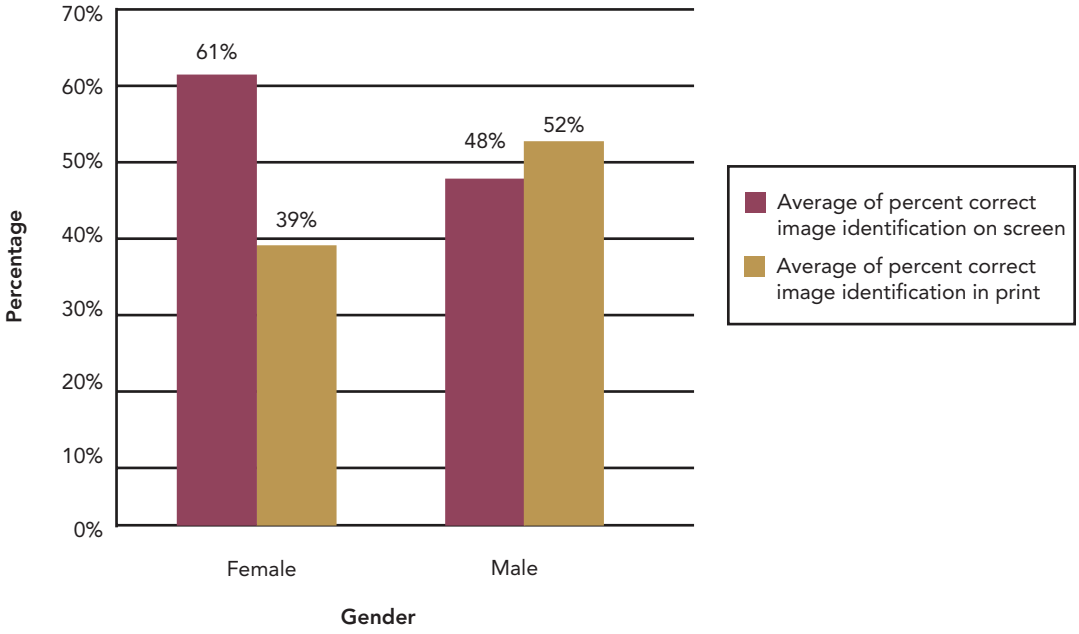

Figure 1-13. Percentage of images correctly identified by presentation medium and gender

Attention Paid to Pictures Taken by Others

Participants were asked whether or not they paid attention to the pictures that they had not taken themselves; 97 percent answered affirmatively. Table B-5 (see Appendix B) shows the answers by participant. Thirty-four percent of the answers are related to a previous experiment where participants were tested at the end of the session, with the same outcome expected this time. The rest of the answers are equally divided between finding the shots interesting and different than their own.

Wanting Pictures Back

Participants were asked whether they wanted their pictures back, and why or why not. Both males and females wanted their pictures back almost three-quarters of the times. Table B-6 (see Appendix B) details the answers, showing that 55 percent of the time participants wanted them back because someone had already paid for them, and they were important, even though they never printed them before. Participants who did not want them back explained almost 40 percent of the time that they were not important images, or that they already had them in digital format, so there was no need to have them also printed.

Summary of Findings of the First Experiment

For this experiment, all participants (with the exception of the first five participants) were first shown digital images, and then printed images. Further experimentation combined both digital and printed images to clarify the suggestion that participants tend to spend more time with the first mode in which they observe the same images.

For this set of participants with this set of images (20 taken by themselves and 12 provided as reference), it was found that males spent more time than females looking at the printed images, while both genders spent essentially the same amount of time looking at the images on-screen. In addition, the results of the first experiment showed that most of the participants preferred printed images, while only one-third preferred images on-screen. Male participants generally have a preference to print their pictures themselves, while females prefer to use print shops and online services. Among the most used printing tools are Kodak EasyShare Gallery, Shutterfly, and Flickr. In addition, Photoshop, Lightroom, and Picasa are used as editing tools, with Facebook mentioned as the main sharing tool. Finally, almost all of the participants wanted their printed pictures back, with the main reason given as the importance of the images in print, even though they did not print these images before for a variety of reasons.

Results of the Second Experiment

Summaries of results from the second experiment, along with responses to survey questions from 32 respondents, are detailed below. Responses to questions related to image viewing, selection, and identification are discussed relative to the demographic findings where possible.

Half of the participants were first shown digital images, then printed images; the other half were first shown printed images, then digital images. For this second experiment, 5-inch by 7-inch images were used. This experiment was conducted to clarify the suggestion from the first experimentation that participants tend to spend more time with the first mode in which they observe the images.

Participant Demographics

A total of 32 students enrolled in the fall and winter Digital Asset Management classes participated in the experiment. This group was comprised of 59 percent females and 41 percent males. The ages of participating students ranged from 19 years old to 22 years old, with a median age of 21 years old.

Almost all of our respondents were in the New Media Publishing program (90%) followed by the Graphic Media program (4%) and the Advertising Photography program (3%). There was no balance of the different programs by gender, which might be an indicator of bias in the preferences.

Medium Preference: Print versus Screen

The participants were asked to carefully review the images. The times spent reviewing the images in both media were recorded, then analyzed. (See Table 1-5.) In general, when looking at the printed images, males spent approximately 13 percent more time than did females; when looking at the images on-screen, males spent approximately 11 percent more time than did females. For all participants, the total time spent looking at printed images was 39 percent higher than the time spent looking at the images on-screen.

Table 1-5. Average times viewing the images by presentation medium and gender

Gender	Average time print (seconds)	Average time screen (seconds)
Males	152	108
Females	134	97
All Participants	143	102

Tables 1-6 and 1-7 show participants' choices of print or screen as the preferred medium for viewing their images in conjunction with whether they spent more or less time looking at their medium of preference. In general, participants did not spend more time looking at what they stated as their preferred presentation medium.

Table 1-6. Medium preferences of males

First: Print	Tp>Ts?		Total
Preference	Yes	No	
Print	0	3	3
Screen	1	3	4
Total	1	6	7
First: Screen	Tp>Ts?		Total
Preference	Yes	No	
Print	0	4	4
Screen	1	1	2
Total	1	5	6
First: All	Tp>Ts?		Total
Preference	Yes	No	
Print	0	7	7
Screen	2	4	6
Total	2	11	13

Table 1-7. Medium preferences of females

First: Print	Tp>Ts?		Total
Preference	Yes	No	
Print	0	1	1
Screen	0	5	5
Total	0	6	6
First: Screen	Tp>Ts?		Total
Preference	Yes	No	
Print	2	4	6
Screen	2	5	7
Total	4	9	13
First: All	Tp>Ts?		Total
Preference	Yes	No	
Print	2	5	7
Screen	2	10	12
Total	4	15	19

As illustrated in Tables 1-6 and 1-7, most of the participants spent more time looking at the images on-screen, regardless of the fact that 56 percent of them said that they preferred printed images.

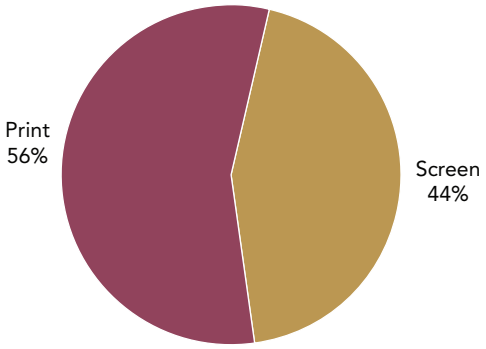

Figure 1-14. Distribution of image presentation preferences

Survey participants were asked to discuss why they preferred one medium over the other, their likes and dislikes regarding their choice, and the issues and challenges of the alternative option.

Twenty-two percent of the participants that preferred images on-screen said they could appreciate more details. Forty-one percent liked images on-screen better due to their quality and bright, shiny, and saturated colors. These results might be correlated to the fact that, for this experiment, larger images (5-inch by 7-inch) were used, as opposed to the 4-inch by 6-inch images used in the first experiment.

On the other hand, the majority of participants (55%) who liked the prints better stated as the main reasons the opportunity to flip through them, to be able to zoom in and out, and to move them around.

When participants were asked whether they ever printed their images, regardless of their medium preference, female participants said that they never print in 75 percent of the cases. Sixty-two percent of male participants also did not print. Sixty-two percent of the participants who print their pictures did spend more time looking at the printed images, while 39 percent of the participants spent more time viewing the images on-screen, even though they often print their pictures. Finally, 61 percent of the participants who never print their images spent more time looking at the pictures on-screen.

Overall, 25 percent said that they do print their images. Among the top reasons for printing were to hang up the images, to place them in a scrapbook, and to give them as presents. These results are very consistent with those of the first experiment. Seventy-five percent of the participants said they did not print, explaining that the main reason is a lack of money to do so. Other reasons for not printing are mass media consumption (such as Internet media, blogs, message boards, podcasts, and video sharing) on computers, and having not much time to print.

Printing Preferences: Self versus Shop

Figure 1-15 shows participants' preferences when they print their images, regardless of whether they currently print. Fifty percent of participants do not have a preference for

printing, while 23 percent prefer to print themselves; the remaining 27 percent say that they would rather use a print shop.

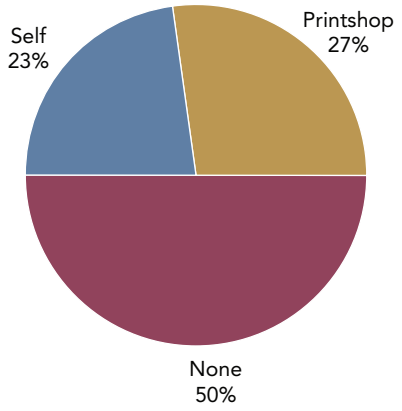

Figure 1-15. How do you print your images?

Participants were also asked whether they had a preference and/or whether they used a special type of paper, ink, and printer for printing purposes. As with the first experiment, none of the participants knew of nor had a preference for paper type. In terms of ink, three participants specified HP, with one saying that high-performance color photo ink must be used. The named printers were HP Photosmart, HP DeskJet 5100, Epson 2900, and HP All-in-One scanner/copier/printer.

When the participants did not print themselves, 35 percent of the participants used Flickr as a printing tool. Tiny Prints, Blurb, Moo, QOOP, and Image Kind were among other mentioned printing services, as in the first experiment. The rest of the participants used Kodak EasyShare Gallery and Shutterfly for printing. In addition, Photoshop, Lightroom, and Picasa were used as editing tools, with Facebook and e-mail mentioned as the main sharing tools.

Printing Practices of Parents

When asked about whether their parents print their pictures and why, 66 percent of the participants answered affirmatively. Thirteen percent of these parents usually printed at home using inkjet printers and regular paper. The remaining 87 percent sent their images to print shops, such as Walgreens, CVS, or other pharmacies. None of the parents added metadata, nor had a backup strategy.

Parents did go back to look at their images in more than 75 percent of the cases, although never to reprint. Participants said that their parents usually find the images they were looking for, especially because of the way they organize their pictures: in albums. Only 16 percent of the participants said that their parents buy photo products (e.g., 60% will buy calendars). Further research into parent preferences would be necessary to draw any conclusions, due the fact that participants did not always know their parents' exact practices.

Wanting Pictures Back

Participants were asked whether they wanted their pictures back, and why. Both males and females wanted their pictures back 85 percent of the time. Sixty percent of the time participants wanted them back because someone had already paid for them, and because the images were important, even though they had never printed them before. Participants who did not want them back explained almost 50 percent of the time that they were not important images, or that they already had them in digital format, so there was no need to have them printed.

Camera Preferences

Almost three-quarters of the participants said that they take pictures regularly (62% of males and 38% of females), with an average of 150 to 200 per event and three to four events in a month.

When asked what type of camera they were using, 7 percent said ultra-compact digital cameras, which are very small, lightweight, easy-to-use, and convenient to carry. Forty-two percent preferred compact digital cameras, which are lightweight and great for point-and-shoot photo-taking. Some compact digital cameras have fully automatic and scene modes; some have semi-automatic and manual controls. Twenty-three percent of the users had advanced digital cameras, also known as "prosumer" digital cameras, that are geared to advanced amateurs with skill levels between a professional and consumer. They sport high-quality lenses and advanced features for creative control. Lastly, 25 percent of the participants owned digital single lens reflex cameras, also known as DSLR cameras, used by professionals and photo enthusiasts. These top-of-the-line cameras have outstanding optics, produce high-resolution images, and accept interchangeable lenses and sophisticated accessories.

The remaining 3 percent either did not own a digital camera or use professional-level cameras from RIT's School of Photography. Favorite subjects to photograph are landscapes (33%), travel (42%), people (17%), and others like plants, sports, and underwater photography (8%).

One hundred percent of the participants keep their images digitally, regardless of their preference to print or not.

Image Storage Practices

Sixty-six percent of the participants will usually keep their images in their computer hard drive in folders organized by date, event, or both. Forty-eight percent of participants routinely backup all their data to an external hard drive. Thirty-seven percent use Time Machine (from Mac OS X Leopard) to take care of backups, while 21 percent utilize online storage as an off-site backup system (Flickr being the most common), and 12 percent burn the images to an optical disc (such as a recordable CD or DVD) on a dated basis, such as one disc per year, quarter, month, etc.

The remaining 34 percent use free image organizers like Xnview (open source) or the popular Irfanview, although the most common ones cited were iPhoto from Apple and Picasa from Google. All of these participants backup their images using an external hard drive.

On average, participants who backup their images do this once every two to three months. Less than 25 percent of them backup every month, and 30 percent backup once a year or never.

None of the participants have ever used metadata for their images. When asked why, more than 50 percent said that they did not know how metadata worked prior to taking the DAM class, and the rest said that it is too time-consuming.

Summary of Findings of Second Experiment

It was found that males spent more time looking at the printed images than females, while both genders spent essentially the same amount of time looking at the images on-screen. Most of the participants preferred printed images, while only one-third preferred images on-screen. Male participants generally preferred to print their images themselves, while females preferred to use print shops and online services. Among the most used printing tools were Kodak EasyShare Gallery, Shutterfly, and Flickr. In addition, Photoshop, Lightroom, and Picasa were used as editing tools, with Facebook mentioned as the main sharing tool. Finally, almost all of the participants wanted their printed pictures back, stating that having the images in print was important, even though they did not print them before for a variety of reasons.

Participants generally kept their images on their computer hard drives in folders organized by date, event, or both. Another common practice was to utilize online storage as an off-site backup system, with Flickr being the most common. Moreover, it was found that the participants make use of free images organizers like Xnview or Irfanview, although the most common ones cited were iPhoto from Apple and Picasa from Google.

Finally, none of the participants have ever used metadata for their images.

Conclusions

This research showed that males spent more time looking at the printed images than females, while both genders spent essentially the same amount of time looking at the images on-screen. In addition, the results of the experiments showed that most of the participants preferred printed images, while only one-third of the participants preferred images on-screen. In the group of participants who did print, male participants generally had a preference to print themselves, while females preferred to use print shops and online services. Among the most used printing tools were Kodak EasyShare

Gallery, Shutterfly, and Flickr. In addition, Photoshop, Lightroom, and Picasa were used as editing tools, with Facebook mentioned as the main sharing tool. Ultimately, almost all of the participants wanted their printed pictures back, with the main reason given as the importance of the images in print, even though many of them did not print their photographs previously for a variety of reasons. The main reasons given for not printing their images were a lack of time and money.

What implications do these findings have? While participants might not print their images at this point in their life, they might revisit their pictures in the future and decide to share and print them then. The results of both experiments showed that participants' parents prefer to print their images almost 100 percent of the time. Could this be a key for the photographic industry to get the message to college-aged young adults that print is another medium to share images?

In terms of image preservation, the outcome of this work illustrated how participants usually keep their pictures on their computer hard drives in folders organized by date, event, or both. Another common practice is to utilize online storage as an off-site backup system, with Flickr being the most common. Moreover, it was found that the participants make use of free images organizers like Xnview or Irfanview, although the most common ones cited were iPhoto from Apple and Picasa from Google. None of the participants had ever used metadata for their images.

In addition, the results of the research showed that a handful of tools to add metadata to photographs are usable as-is, but many of these tools need more work to become applicable in a variety of environments. Significant development from the industry is required to create a robust and well-defined set of metadata remediation services that would be attractive to users.

Participants explained that organizing their photos is a complex problem. Generally, the software that comes bundled with digital cameras provides some basic photo management functionality. Companies like Adobe and ACDSee offer robust applications that enable editing, managing, and annotating the images in digital photo albums. Flickr provides the same sort of functionality on the Web, simplifying the process of publishing photos for public consumption. On the other hand, relatively few tools are available that can work directly on the metadata records of consumer photographers. The geographic location where an image was taken is one of the key pieces of information that consumers want to capture. Until recently, location capture was often accomplished with post-creation keyword annotation. With the advent of embedded GPS, accurate location information can now be automatically inserted into image files at creation time and merged with applications like Google Maps. Exif, IPTC-IIM, IPTC Core, IPTC Extensions, and XMP all specify metadata properties that capture, with varying degrees of accuracy, either the location of the camera or the location of the image subject.

Keywords are used across software applications today. However, keywords (also called "tags") are often not used correctly, if they are used at all. Applications overload the tags with general-purpose information exchange, such as for workflow or task management

While all of these solutions work for today and tomorrow, they ignore a bigger, longer-term issue: How are these photos going to be shared and stored in 50 years? One thing that consumer electronics has taught us in the last twenty years is that formats change, and they change quickly. However, for digital photographs, the problem is two-fold. Not only is there the need to worry about the storage medium (whether that means hard drives, a library of CDs, or on-line), there is also the need to worry about the file formats. Most photos are stored as JPEG files. JPEG compression has been around for a while, and history teaches us that there will eventually be a new format that will replace JPEG.

So, what is a college-aged photographer to do? One answer might be to go with the most reliable, future-proof technology available to humanity at this point in time. It has a proven track record and very minimal storage requirements. It is called 'paper.' Companies need to develop easy-to-use solutions that enable the printing of products that are attractive to this age group. The other answer might be to invest in robust, easy, and automated metadata tagging and for-pay cloud storage solutions that will allow today's college-aged photographers to share their photographs with future generations. All of this will not be possible without increased consumer education and the development of easy-to-use end-to-end solutions.

Part II: An Experimental Study of Differences in Reading Photo Books by Presentation Media: Print versus Screen

by Ya-fang Tsai and Frank Cost

Part III: What are You Looking at? Evaluating Observer Eye Movements as They Look at Images in Print and on Computer Screens

by Susan Farnand

Abstract

The advent of digital print engines capable of achieving high image quality has opened up many new and exciting print product opportunities, including the short-run printing of magazines. However, content available for magazines is also readily available on-line. It is not immediately obvious that the capability of creating a short-run magazine translates into a viable business model; just because they can be printed does not necessarily mean that it makes sense to do so. The objective of this project was to take the first steps toward identifying and understanding the differences in how information is consumed from print on paper versus computer display and which characteristics of these media are particularly relevant in this comparison. Longer-term, it is intended to explore how such differences affect the efficacy of magazine advertising. This evaluation involved an assessment of differences for several metrics, including information retention, time taken to view images, preference for visually consuming information, and distribution of visual gaze as measured by eyetrackers.

Experimentation was conducted that focused on the first three of these four factors (Part II). Experimentation in Part III generally confirmed the results of this study: specifically, that people preferred the hard copy rendition over a PDF when given the choice (for reasons of image accessibility and tangibility), and that neither the time used to view the photo books nor information retention as measured by image recognition and information recall were affected by the medium in which the photo book was seen. The results of this study also agreed with earlier research findings that observers tend

to fixate first and most often in the central areas of images. This research also found, however, important differences between how the observers viewed the printed and screen versions of the photo book, with the screen group having more fixations per image for many of the images early in the book (though not spending more time with these images), while the print group switched more often between images. While the work conducted in Part II suggested that there were no important differences between the print and screen groups of observers, the results of Part III hint at differences that may be important with regard to individual images or image layouts. Further work involving image content with a more balanced mix of text and pictorial imagery might prove useful in exploring these findings further.

Introduction

In recent years the image quality obtainable on digital print engines increased to a level such that many printing tasks once closed to technologies other than offset lithography are now available. Further, there now exist opportunities that were, until recently, not technologically feasible. One such opportunity is the short-run or even personalized printing of magazines. The objective of these projects were to work toward understanding the differences in how people consume information on-screen relative to the printed page. In addressing questions concerning the consumption of information on-screen compared to that of the printed page in the past, relative reading speed has been the focal criterion. While this is an important consideration, when the focus shifts from text typography to advertising, other factors become more critical to understand. Factors that differentiate the reading experience on-screen versus on paper that may be of interest when comparing advertising efficacy on these media include gloss, flare, texture, image contrast, color gamut, physical layout of the advertisement, and physical comfort, among others. To develop an understanding of the differences in efficacy of print on paper versus on-screen, it is essential to also understand which characteristics of these two media are particularly relevant when comparing the consumption of information on paper versus on-screen.

The goal of a first experimentation was to determine if people, when given a choice, will select to read printed images in a photo book or electronic images on a screen; this is described in Part II of this monograph. In a second experimentation, (described in Part III) the possibility of using distribution of visual gaze as measured using eyetrackers is evaluated as a possible metric to employ in an exploration into the relative contribution of various factors such as gloss, color, and print layout to the impact of advertising on-screen versus in print. Information retention, time used to view images, and preference for visually consuming information were also evaluated.

Part II: An Experimental Study of Differences in Reading Photo Books by Presentation Media: Print versus Screen

by Ya-fang Tsai and Frank Cost

Statement of the Problem

"Before the digital age, about 90 percent of all images captured were printed in one form or another," says Grevas (2008). Compared to conventional camera users who print most images, digital camera users print about one-third of their digital images (Photo Marketing Association International [PMA], 2009b, p. 10). In 2008, 61 percent of digital camera users made photo prints (PMA, 2009b), while only 5 percent of camera phone users made photo prints (Henning, 2008, p. 4).

Since digital images can be shared at little cost on the Internet, it is easy for digital camera users to upload photos to web-based albums instead of printing them. Viewing photos on computers is easier and cheaper than making photo prints. However, products personalized with photos are a growing market. In 2008, 57 percent of U.S. households made photo-finishing products, while 16 percent made photo books (PMA, 2009c, p. 2-3). For photo books to grow, people must value printed photos more so than pictures on the screen. The question therefore becomes, do people interact with pictures in photo books differently from those on the screen? Also, will people print photographs in the future? They will if the tangible form of the printed image is preferred to the electronic form of the image on the screen. The purpose of this research is to determine if people, when given a choice, will select printed images or electronic images.

Background

With traditional photography, developing photographs was the only way to share images. Now, with computers and digital cameras integrated into people's daily lives, viewing images on a monitor is a common and effortless way to share images with others (PMA, 2009b). The benefits of digital photography are its immediacy and versatility.

> "The very media of digital photography opens new opportunities for communication. Once digitalized, a photograph is almost infinitely malleable, much like a clay sculpture in process" (Johnson, 2006).

Is there a sustained value in printed pictures today? Do people treat pictures on a screen differently than they treat printed photos?

Reading Online versus On Paper

Previous research indicates that people read faster on paper than from a screen. In Kuruniawan and Zaphiris's (2001) study, they showed that reading text from a monitor was 10 to 30 percent slower than reading from paper. In a study by Spencer (2006), students preferred print copies of textbooks because of portability, dependability, flexibility, and ergonomics. In addition, he found that reading on paper was more convenient than from a screen because paper was faster to access. Paper was also easier to highlight and annotate.

In a study of e-book use (Gregory, 2008), students liked e-books for their convenience, cost, and ability to print particular pages. Students could print only the pages they needed from e-books, which saved paper and cost less than a traditional textbook. However, students disliked e-books because of navigation (confusing menus), eyestrain, and the preference of having a book on hand. Portability is also a concern—people can bring books anywhere, even without electricity or an Internet connection, while these might be needed to use an e-book reader. The study also showed that people have better concentration when reading printed books.

In summary, the research discussed above found that reading from a book was superior to reading from a screen.

Viewing Photos on Monitors

No research has been conducted on viewing photos on paper versus on a screen. However, market trends show that people like the technology options available to them. With digital images, sharing photos electronically is done through web-based albums or e-mails (Miller & Edwards, 2007). "Compared to the cost and effort of print duplication, it is very easy to e-mail others photos and links to online albums" (Greenberg, Neustaedter, & Nunes, 2008). According to the *2009 PMA U.S. Consumer Photo Buying Report,* 99 percent of U.S. households stored digital images, 11 percent shared photos online, and 19 percent e-mailed digital images saved on their computer (PMA, 2009a). Furthermore, with 74 percent of U.S. households owning digital cameras, 7 percent have digital picture frames (Gretzner, 2008). Digital picture frames are expected to have huge growth in the future (Gretzner, 2008), thereby indicating that consumer preferences tend to change with technology.

Printing Photographs

According to the *U.S. Photo Industry 2009: Review and Forecast,* 35 percent of saved digital photos were printed in 2008, and this number is expected to decline to 32 percent in 2009. However, the absolute amount of printed digital images is expected to grow from 8.6 billion images in 2008 to 8.7 billion images in 2009 (PMA, 2009b, p. 10). The absolute number is rising as more consumers become digital camera users.

Nevertheless, digital photography has not entirely replaced physical photos, because people still make photo prints for family and friends as gifts or souvenirs (Boll & Henze,

2008). Compared to printing photos in the film age, the reasons for making photo prints are more 'purposeful' in the digital age. One popular photo-finishing product is a photo book. The main reasons for producing photo books are given below, according to the *2009 PMA Photo Book Report:*

> "… [T]he majority of households (69%) make photo books as family keepsakes, followed by 37 percent who make them for the purpose of showing pictures to others and 32 percent who give them as gifts to family and friends" (PMA, 2009c, p. 1).

Current Issues and Trends

The photo book market grew by 22 percent in 2008, and it is expected to grow to 26 percent in 2009 (PMA, 2009c). More than half of photo books produced were in 4-inch by 6-inch or 5-inch by 7-inch sizes, either as paperback or hardcover books. However, many photo book customers did not finish editing their photo books. The reasons ranged from "It takes a long time", "It is difficult to process", and "They don't have enough pictures", to "They intended to finish it later" (PMA, 2009c). As Frey says,

> "A successful strategy to create products from digital images must combine the consumers' desire to keep their memories with new and easy workflow solutions to create these products" (Thall, 2009).

Conclusion

The benefits of printed photos are that they are tangible and long-lasting, while the benefits of digital pictures are they are fast to create and easy to search (Martinez, 2008). A question remains as to whether the benefits of printed photographs are valued over the benefits of electronic images? Therefore, this research will examine how people interact with photos in print versus on-screen. When given a choice, which modality will they prefer?

Research Objectives

The primary question that this experiment will seek to answer is: Are there any fundamental differences in the way people interact with photographic content presented in print versus on-screen?

The ways that this interaction will be measured are:

- **Behavioral** – Will people choose one medium over the other?
- **Cognition** – How much time will they spend with the content? How much of it will they remember?

Methodology

Sampled Population

The study was conducted during the spring quarter of 2009 in the College of Imaging Arts & Sciences (CIAS) at Rochester Institute of Technology (RIT). Sixty-four subjects volunteered to participate in the study from two classes: Digital Asset Management and Typography & Page Design.

Experiment Limitations

These subjects, who were all imaging major students, were randomly separated into two groups. Because the initial sampling was not random, it is not possible to generalize the results to a broader population.

Stimulus Design

The photo book used in the experiment was designed with 21 photographs and captions in landscape format (see Appendix C). The amount of content in the book was adjusted (by pre-experiment testing) to be readable in less than ten minutes. The photographs were all of Rochester, NY landmarks and subjects familiar to anyone living in the area. The printed publication was a 7-inch by 9-inch landscape-format saddle-stitched paperback book, which was printed using Lulu.com. A 12-inch computer screen was used to display the photo book in PDF format. The size of pages displayed on the monitor was the same as in the printed book. Participants were able to view the electronic version of the book page-by-page by using the "page up" and "page down" keys on the computer keyboard.

Procedure

Half of the subjects participating in the experiment read the printed book only. The other half read the electronic book only. Each of the two formats was read by 32 subjects.

The experiment was conducted over a period of three weeks. Subjects were distributed between the two presentation media so that both groups had equal distributions of gender, auditory capability, and English as a first language. Participants signed up for a specific hour-long session during the three-week period. Participants were advised not to talk about the experiment with their colleagues after taking the survey, as it was important that participants were unaware of the content in the test until it was their turn to participate in the experiment.

When the participants arrived for their session, reading instructions were provided. Participants were instructed to look through the content carefully in preparation to take a test regarding the content of the book. Participants were instructed to take as much time as they need to review the contents. A timer was started when the participant

began, and the participant was asked to press the stop button on the timer when he or she had finished. At that point, the book or computer display was removed from sight and the test was administered.

The test included 22 questions (see Appendix D). Twelve questions were used to test the amount of recall. These questions were about the content and format of the book. The other ten questions were used to test the amount of recognition. These questions were about the test images used in the book. The subjects had to determine whether the images shown were the same as in the book. Four of the images were exact matches. Three were similar photographs of the same content from slightly different viewpoints. The other three were completely different photographs, but with possible logical associations to the ones in the book. The interviewer recorded the answers provided by the participants verbally.

When participants concluded the experiment, they were offered either a copy of the printed book or a PDF sent via e-mail to keep for their participation in the study. Participants were also asked why they selected the particular medium to keep. The choice each participant made and the reasons for their preference were recorded. Three weeks later, participants received their choice of either the printed book or PDF once the experiment was concluded. This prevented other participants from seeing the content before taking part in the experiment.

The data gathered were then added to a spreadsheet that contained one row of data for each coded participant. The columns of the spreadsheet included the type of media presented (print or electronic), elapsed time for reading, responses to each question in the test, choice of medium (print or PDF) and the reasons for the choice.

The data were then analyzed using a chi-square test and a *t*-test. For the choice of medium preference, a chi-square test was used to compare the frequencies of choices. For the time spent interacting with the book and the cognition test results, a *t*-test was used to test the means of both samples.

Discussion of Results

Behavioral Results— Medium Preference

Of the 62 subjects who made a choice as to what version of the book they wanted to keep, 74 percent selected the printed book and 26 percent selected the PDF. Table 2-1 shows that there was a difference in preference. Of the 32 subjects who were shown the printed book, 29 selected the book and the other three selected the PDF. Of the 30 subjects who were shown the PDF, 17 selected the book and 13 selected the PDF.

Table 2-1. Choice of medium by medium shown

Medium/Choice	Shown Book	Shown PDF	Overall Preference
Selected Book	29	17	46
Selected PDF	3	13	16
Total	32	30	62

To test whether there was a difference in choice by presentation modality, a chi-square test was used (for calculation details, please see Appendix E). The result was statistically significant ($\chi^2 = 9.33 > \chi^2.05 = 3.841$). Thus, the presentation medium shown and the subjects' choices are related. More participants selected the PDF when shown a PDF, even though more participants overall selected the book.

The reasons for selecting each medium are presented in Table 2-2. Results show that "tangible", "prefer hard copies", "easier to keep PDF", and "easier to look/flip/show" were the top three reasons for choosing the book to keep, regardless of whether participants were shown the book or the PDF. For those who were shown the book, "tangible", "prefer hard copies", and "easier to look/flip/show" were the top three reasons for choosing the book to keep. For those who were presented the PDF, "tangible", "prefer hard copies", and "easier to keep book" were the top three reasons for choosing the book to keep. "Easier to keep PDF" and "easy to access/carry PDF" were the top two reasons for choosing the PDF to keep.

Table 2-2. Reason for choice of medium by medium shown

Reason for Choice	Medium Shown				Total
	Shown Book		Shown PDF		
	Selected Book	Selected PDF	Selected Book	Selected PDF	
Tangible	9		10		19
Prefer hard copies	6		3		9
Easier to keep PDF		2		5	7
Easier to look/flip/show	6		1		7
Easy to access/carry PDF				6	6
Easier to keep book	1		3		4
Free	2		1		3
Print quality	2				2
More valuable	2				2
PDF=homework					
Book=leisure	2				2
Don't like to look at content on-screen			2		2
Easier to show PDF		1			1
I don't like printed photos				1	1

Cognition Results

Time Spent Interacting with Images

Table 2-3 shows that the average time spent interacting with the book was 5.034 minutes and the average time spent interacting with the PDF was 4.765 minutes. The time spent is almost equal. To test for relation to the presentation modality, a *t*-test was used. The results were not significant ($t = 0.4012 < t.05 = 1.67$). Thus, the time spent interacting with the images was not related to presentation modality.

Table 2-3: Time spent interacting with images by presentation modality

Test#	Subject#	Book Test (mm:ss)	Subject #	Screen Test (mm:ss)
1	1	03:51	3	01:47
2	2	04:14	4	05:40
3	6	07:14	5	06:07
4	7	03:10	9	02:29
5	8	07:20	10	05:02
6	11	05:41	16	04:06
7	12	03:38	17	02:21
8	13	05:52	18	02:53
9	14	02:59	21	04:00
10	19	02:42	22	05:15
11	20	07:30	23	03:32
12	24	02:19	25	07:42
13	26	16:15	29	04:47
14	27	01:25	30	02:05
15	28	07:05	31	05:01
16	32	09:20	34	04:46
17	33	04:11	35	02:50
18	36	02:38	37	04:21
19	39	01:47	38	11:32
20	40	04:47	43	04:02
21	41	02:10	48	03:28
22	42	04:40	49	04:33
23	44	04:11	53	03:20
24	45	10:13	54	07:19
25	46	05:03	55	04:03
26	47	05:06	57	06:55
27	50	06:42	58	02:54
28	51	03:01	59	07:21
29	52	03:10	60	02:06
30	56	03:01	61	10:50
31	63	05:39	62	02:54
32	65	03:58	64	06:03
Mean Value	--	5.034 min	--	4.765 min

Recall and Recognition Test

For the recall results in the first part of the test, subjects were asked to agree with statements that described the photos presented. As shown in Table 2-4, an average of 66.88 percent of participants who were shown the book answered the 10 questions correctly, while 65.63 percent of those shown the PDF answered them correctly (N=64). For the recognition results in the second part of the test, subjects were shown ten images and asked if they were exactly the same as they were in the photo book (see Appendix D). Table 2-5 shows that an average of 77.50 percent of participants who were shown the book answered the ten image questions correctly, while 76.56 percent of those shown the PDF answered the questions correctly (N=64). To test for statistical significance, a *t*-test was used. The results were not significant (for Table 2-4: $t = 0.1317 < t.05 = 5.991$; for Table 2-5: $t = 0.0703 < t.05 = 5.991$). Therefore, recall and recognition were not related to presentation modality.

Table 2-4. Percent of correct replies by presentation modality for the recall test

Questions	Book	Screen
1: Which of the fonts below is used in the photo book?	37.50%	28.13%
2: What are the weather conditions in the photo of the Highland Park Diner?	87.50%	81.25%
3: What are the people doing in the photo taken in Highland Park?	78.13%	71.88%
4: In the aerial view of RIT's campus, are the parking lots full or empty?	65.63%	56.25%
5: At what time of day was the picture of Cobbs Hill Reservoir taken?	59.38%	62.50%
6: How many people are in the picture of the Little Theatre Café?	34.38%	53.13%
8: What is the color of the car in the Henrietta Wal-Mart parking lot?	96.88%	93.75%
9: How many bridges are visible in the picture of Dinosaur Barbeque?	46.88%	46.88%
10 What color are the shirts people are wearing in the photo of the concert at the Hochstein School of Music and Dance?	81.25%	75.00%
11: The High Falls at Dawn, Noon, Dusk, and Night: which two pictures are not in the photo book?	81.25%	87.50%
Average	66.88%	65.63%

Table 2-5. Percent of correct replies by presentation modality for the recognition test

Images	Book	Screen
Image 1	62.50%	37.50%
Image 2	100.00%	96.88%
Image 3	87.50%	100.00%
Image 4	90.63%	87.50%
Image 5	53.13%	53.13%
Image 6	96.88%	96.88%
Image 7	78.13%	90.63%
Image 8	12.50%	9.38%
Image 9	93.75%	96.88%
Image 10	100.00%	96.88%
Average	77.50%	76.56%

Conclusion

The goal of this research was to investigate the differences in interacting with photo books by presentation modality. In previous research, reading text online was 10 percent to 30 percent slower than on paper (Kuruniawan & Zaphiris, 2001). There was no prior research about how people interact with photos, but market trends show that people are using electronic images more.

In this study, people were shown photos in a book or on a screen. The level of interaction was measured in two ways:

- **Behavioral** – Will people choose one medium over the other?
- **Cognition** – How much time will they spend with the content? How much will they remember?

A test to determine recall and recognition was administered after each participant was shown the photo book. The results were as follows:

- There were no fundamental differences in the way people interact with photographic content presented in print versus on-screen.
- **Cognition:** The amount of time spent reading the content and how much people remembered were not related to the medium modality.
- **Behavioral:** Overall, participants preferred the printed book to the PDF. However, of those shown the PDF, more selected it.

Implications for Photo Finishing

In the digital age, making photo prints is more purposeful than in the film age, with purposes in mind such as gift-giving or family keepsakes. This experiment shows that "the physical touch of printed photos is still appreciated" (Boll & Henze, 2008). Photo-finishers can demonstrate samples of printed photo books and other personalized products, which would attract people to make photo prints and/or products.

However, participants shown the electronic version were more likely to select the PDF. This may indicate that, as people get used to viewing photos on-screen, they may adapt to the new technology at the expense of the old. Photofinishing may see a downward trend as a result.

Part III: What are You Looking at? Evaluating Observer Eye Movements as They Look at Images in Print and on Computer Screens

by Susan Farnand

Background

Much of the past effort evaluating the consumption of information in print versus on-screen has focused on the differences in reading. The resolution of early computer screens was low enough to significantly impact reading speeds relative to print. For this reason, reading speed was most often the metric of choice in comparing these media. Additionally, images on-screen were certainly not pervasive until recent years.

In work conducted to evaluate the differences between print and screen reading for work-related purposes, researchers found that print offered advantages with regard to annotation, navigation and spatial layout, and that spatial location is important for readers, leading to increased comprehension (O'Hara & Sellen, 1997; Adler, Gujar, Harrison, O'Hara & Sellen, 1998; O'Hara, Sellen & Bentley. 1999; Terrenghi, Kirk, Sellen & Izadi, 2007). The work conducted in this experiment will not provide additional information with regard to reading; however, the results may be important in understanding the spatial layout and navigational differences between viewing extensive documents such as photo books and magazine articles in print relative to viewing such documents on computer displays.

In the past year, Tsai and Cost have also conducted experimentation evaluating differences in the viewing of photo books in print versus on computer displays (see Part II of this monograph). The results of their study concluded that participants preferred printed books in general, although a significant proportion of the observers shown the images on-screen selected the PDF version to keep. The most common reason cited regarding this preference was the tangibility of the printed form. The researchers also found that there were no statistically significant differences in time spent viewing the images or the observers' ability to recall information contained in the images based on the medium in which the images were presented.

Frey and Rodriguez Adames conducted similar work using printed and displayed photographs (see Part I of this monograph). In this experimentation, all of the observers viewed both digital and printed images. These researchers found that participants preferred to view printed photographs over electronic ones by a margin of

59 percent to 38 percent. The reasons cited for this preference included that the images were tangible, easier to flip through, had more vibrant color, were sharper (though participants selecting the PDF images cited these latter two reasons as well in making their selection), and were glossier. The researchers also found that image modality had little effect on the time spent looking at the images.

The key difference between this experiment and those performed by Tsai and Cost and Frey and Rodriguez Adames was that the evaluation of observer gaze distribution was added. Although it has been possible to record eye movements for about a century, the equipment historically available required constraint of the head to prevent movement during acquisition of this data, making this a difficult, unnatural, and, at times, even painful process. Recently, however, an eyetracker has been developed at the Rochester Institute of Technology by Pelz and colleagues that allows the observer to move more freely (see Figure 3-1).

This wearable eyetracking equipment, currently available from Positive Science, LLC, was used to record the observers' eye movements while they viewed the book. This equipment, described in detail in several publications (i.e., Babcock & Pelz, 2004), consists of a pair of eyeglasses with the lenses removed to which two tiny video cameras have been attached. One of these cameras points toward the observer and records the movements of the observer's right eye, while the other camera points away from the observer and records the scene which the observer is viewing. Using information from the eye camera regarding the location of the center of the pupil and the first-surface corneal reflection, the observers' gaze position within a given scene can be determined. The eyetracker system yields a video record of the scene overlaid with a cursor that traces the path of the observer's point-of-regard, as shown in Figure 3-2.

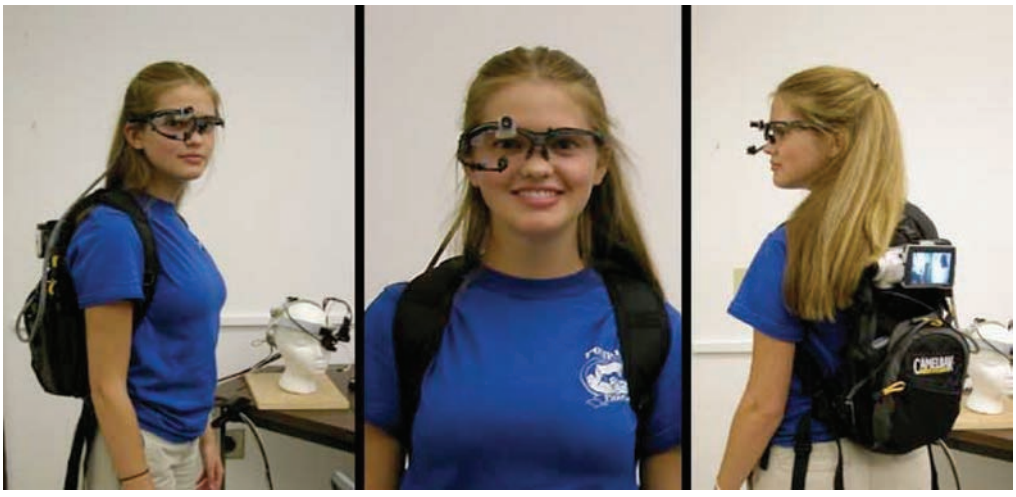

Figure 3-1. The wearable eyetracker, developed at RIT

Figure 3-2. Screen shot of the video recorded by the eyetracker system showing the scene from the observer's perspective along with the observer's right eye while viewing the printed version of the photo book used in the experiment

Experimental Methodology

This experiment consisted of having an equal number of participants view printed and electronic versions of a photo book. The book used in this experimentation was the same book that was used in the experimentation by Tsai and Cost. This book consisted of 21 images of Rochester landmarks in 7-inch by 9-inch landscape orientation with accompanying captions (see Appendix C). The hard-copy version was printed in duplex mode so that observers saw two pages at a time as they might with a printed magazine. The observers held the book as they might a pamphlet or magazine and maintained control of turning the pages. In comparison, with the electronic version the observers viewed one image at a time on a 12-inch diagonal LCD computer screen. Observers controlled navigation using the computer's arrow keys.

Time spent with the images, information retention, image modality preference, and gaze distribution were evaluated. The first three metrics were measured in the same manner as they were in the experimentation by Tsai and Cost and Frey and Rodriguez Adames. The time each participant spent looking at the images was recorded. To evaluate the information acquired while looking at the photo books, the observers were asked to answer ten detailed questions regarding the content in the images. These were the same questions that were used by Tsai and Cost (see Appendix D). Also, as in the experimentation by Tsai and Cost, the observers were shown ten images and asked whether or not each appeared in the book. Four of the images did appear in the book, three were very similar to those that appeared in the book, and three were quite different from those that appeared in the book, although they did contain Rochester landmark content.

Fourteen observers participated in this experiment. All of the observers were high school juniors and seniors who were working as summer interns in the Imaging Science program at the Rochester Institute of Technology. Eight were male and six were female. Seven viewed the photo book on-screen and seven viewed it in print.

Prior to initiating the experiment, observers were given information on their rights with regard to research using human subjects as well as the instructions for the experiment. When informed consent had been obtained, the observers donned the eyetracker headgear and calibration of the headgear was performed. When satisfactory calibration was achieved, the experiment began. Each observer was given either the printed book or the electronic book on the computer display to view. All of the observers were instructed to look through the book as they might a magazine or other photo material. After viewing the book, the observers were questioned regarding the material that they had seen. They were asked to:

- Identify images as being included in the book or not.
- Describe the image that they remembered the best.
- Decide whether they would prefer a printed or PDF version of the photo book as a token of appreciation for participating in the study.

The video files acquired during the experimentation were evaluated using RITcode software to identify the fixations made by each observer. Using this software, each of the fixations in the video was labeled according to the region of the given image in which it occurred. All 21 images in the photo book were divided by subject matter into as many as twelve regions. The regions identified for each image are listed in Table F-1 (see Appendix F). Information on where the fixations occurred, the first and last fixations, total fixations, the number of switches between images, and the number of fixations off-image were collected for each observer.

It should be noted that the tasks assigned to the observers were quite different between the three studies. In the Tsai and Cost study, the observers were asked to study the images and were advised that they would be questioned about them after they had examined the photos. In the Frey and Rodriguez Adames study, participants were asked to carefully review the images. In this study, the observers were told to look at the photo books as they might a magazine. Nothing was said ahead of time regarding the questioning that would take place.

Results

In this experimentation, information on the same metrics evaluated by Tsai and Cost—image mode preference, time taken to view, and image content recall—was collected. Looking first at image mode preference, in this experiment it was found that observers strongly preferred the print over the PDF version of the photo book. Nearly 80 percent of the observers selected the printed book, while only one of the fourteen observers selected the PDF. Two participants were not interested in either version, as shown in Table 3-1. The result seen in Tsai and Cost's experimentation of a rise in the number of those who selected the PDF after being shown the electronic book did not occur in the

present experiment. (However, the number declining either choice did increase for this group.) However, the number of observers included in this study was only a fraction of that of the previous testing, so this trend may not have been evident with this smaller number of observers.

Table 3-1. Image modality preferences of participants

Selection	Shown print	Shown PDF	Overall
Selected print	6	5	11
Selected PDF	1	0	1
Declined	0	2	2
Total	7	7	14

The most mentioned attributes for those that selected the print version were accessibility and tangibility. They felt it would be easier to show family and friends, that a computer would not be needed to view it, and that it was easier to flip through. They also cited tangibility, stating that they liked to have something to hold. The observer selecting the PDF commented that he would not look at it often and "did not want to use up [our] resources."

The image medium did not have an impact on the average time spent with the photo book, as shown in Table 3-2. The mean times were essentially the same, at approximately four minutes and forty seconds. These results are in agreement with Tsai and Cost, who likewise found that medium did not impact the time spent with the book and that the mean was approximately five minutes. In this experiment, there was a difference in the variation around those means for the different groups. The time spent with images by the observers viewing the printed book varied widely, having both the shortest time and the longest time. The screen group was much more tightly grouped, only varying from the average by about a minute at most as opposed to a variation of three or four minutes for the print group.

Table 3-2. Time spent with the photo book by observer and version shown

Observer	Print (mm:ss)	Screen (mm:ss)
First	05:15	05:10
Second	06:00	04:20
Third	02:12	06:48
Fourth	03:38	05:15
Fifth	01:35	03:45
Sixth	05:45	04:30
Seventh	08:50	04:10
Mean	04:45	04:41

It was also found that the medium did not have a significant impact on image recognition. The observers who saw the printed photo books correctly identified 89

percent of the images, while the observers who saw the images on the computer display correctly identified 91 percent of the images as shown in Table 3-3. This difference is not statistically significant. These results are in agreement with those of Tsai and Cost, though the observers in this experiment had a higher percentage of correct answers than those in that experiment—about 90 percent in this experiment compared to about 77 percent for the Tsai and Cost observers. This difference was driven primarily by the *Diner* image, which the observers in this experiment correctly identified as being slightly different from the image in the book about 55 percent of the time, while the Tsai and Cost observers incorrectly identified this image as being in the book about 90 percent of the time. This test image was the eighth of ten images in the Tsai and Cost testing, whereas it was seen second by the observers in the present testing. This difference in image order may have impacted the overall results.

Table 3-3. Percentage of correctly identified images by relation to the book and observer group

Image	Relation to book	Print	Screen
RIT	Similar	100.0%	85.7%
Diner	Similar	42.9%	71.4%
Lilac Festival	Different	100.0%	100.0%
Monroe Ave	Same	85.7%	100.0%
Corner of Main St	Same	100.0%	100.0%
Charlotte Pier	Similar	85.7%	85.7%
Reservoir	Different	100.0%	100.0%
Little Theatre	Different	100.0%	100.0%
High Falls	Same	85.7%	85.7%
Artisan Works	Same	85.7%	85.7%
Mean	--	88.6%	91.4%

The impact of the medium on the observers' ability to recall information from the photo book was less clear. The difference in results between the observers shown the printed version and those shown the electronic version was larger for the questions on scene content. The print group correctly answered 53.8 percent of the questions while the screen group correctly answered 71.4 percent, as shown in Table 3-4. This difference is statistically significant at a 90 percent level. However, it is important to remember that the number of observers was low. One of the print group's observers had a very low percentage of correct answers, which, with only seven observers, significantly impacted the results (closer to an 80% probability of a statistically significant difference without this observer). Tsai and Cost found that the medium did not impact the percentage of correct responses made by the observers, with both groups at a level of about 66 percent correct, similar to that achieved by the screen group in this experiment.

One other interesting result from the data reported in Table 3-4 was that the two questions that were most often answered correctly both pertained to color: the color of the car in *Parking Lot* and the color of the shirts in *Hochstein*. This may be because

recognizing color requires a lower level of cognitive processing than determining the time of day, weather conditions, or counting the number of items as asked in some of the other questions. The only other question that did not require some level of deduction regarded the hairstyle of the man pictured on the video game in the *Rec Center* image.

Table 3-4. Percentage of correctly answered questions on image content by observer group

Image	Print	Screen
Diner	57.1%	71.4%
Highland Park	28.6%	71.4%
RIT	28.6%	42.9%
Reservoir	28.6%	71.4%
Little Theatre	28.6%	28.6%
Rec Center	42.9%	71.4%
Parking Lot	85.7%	100.0%
Dinosaur BBQ	57.1%	57.1%
Hochstein	85.7%	100.0%
High Falls	78.6%	92.9%
Mean	52.1%	70.7%

The number of observers was generally too small to identify statistically significant differences with regard to time spent and memory. For answers to these questions, the work of Tsai and Cost provides a more relevant analysis. The present work essentially confirmed the results of this earlier work. Of greater interest in this experimentation were the parameters pertaining to the gaze distributions made on the images by the two groups of observers. It was of interest to the researcher to understand where observers were looking in the images and to identify differences in the viewing patterns of the two groups.

Looking first at the number of fixations for both groups of observers, we see that the screen group had significantly more fixations per image than the print group. There were 22.6 fixations per image on average for the screen group as compared to 17.6 for the print group. This was a statistically significant difference at a probability of greater than 99 percent following a *t*-test procedure. Additionally, the fixations for the two groups by individual images were highly uncorrelated, with a correlation coefficient of 0.20 as shown in Figure 3-3. It is evident from the data plotted in Figure 3-3, however, that there are a few distinct groups of images, which tend to be a function of the images' location in the photo book.

For the first two images, the fifth image, and the *Cellino and Barnes Banner* image, (represented by the red squares in Figure 3-3), the screen group of observers had a much higher mean level of fixations than the print group, about 13 more fixations per image (70%-115% higher). The screen group also had approximately a 45 percent

higher level of fixations for the *Cellino and Barnes Billboard* image, the last image in the book, and five of the earlier images in the book (shown as gold squares in Figure 3-3). For most of the remaining images—from the ninth to the twentieth images in the book, shown as the blue squares in Figure 3-3—the screen group had only about a 10 percent higher level of fixations. Three of the images very late in the book—*Artisan Works, Cinema Theater*, and *Lipstick Aisle*—were the only ones for which the print group had slightly higher fixation levels than the screen group.

When the images are separated in this manner, the performance between the two groups of observers is quite well correlated, with a correlation coefficient of around 0.95. Looking then at the difference between the mean number of fixations for the screen group and the print group over the course of the book (see Figure 3-4), there is a general downward trend until the *Artisan Works* image, after which the difference increases again to the end of the book (with the *Sledding* and *Cellino and Barnes Banner* images being clear exceptions to this trend). It is unclear why this difference in performance occurred. While the print group had some indication of how many images were still to come in the book from the feel of the pages, the screen group had no idea. Perhaps this difference influenced the way that they looked at the images. Then again, this trend might not hold up in a larger sample. It would be interesting to alter the order of the images and see if the differences followed the individual images or if the general trend still held.

Observers in the screen group had a higher number of fixations, on average, when viewing the photo book. Since the total time spent with the book by the two groups was roughly equivalent, the screen group had more fixations per minute. This indicates that they moved their eyes around more in each image, possibly moving back and forth between elements and spending less time looking at each one. In contrast, the group viewing the printed book spent more time looking at each region that caught their attention prior to moving on to the next.

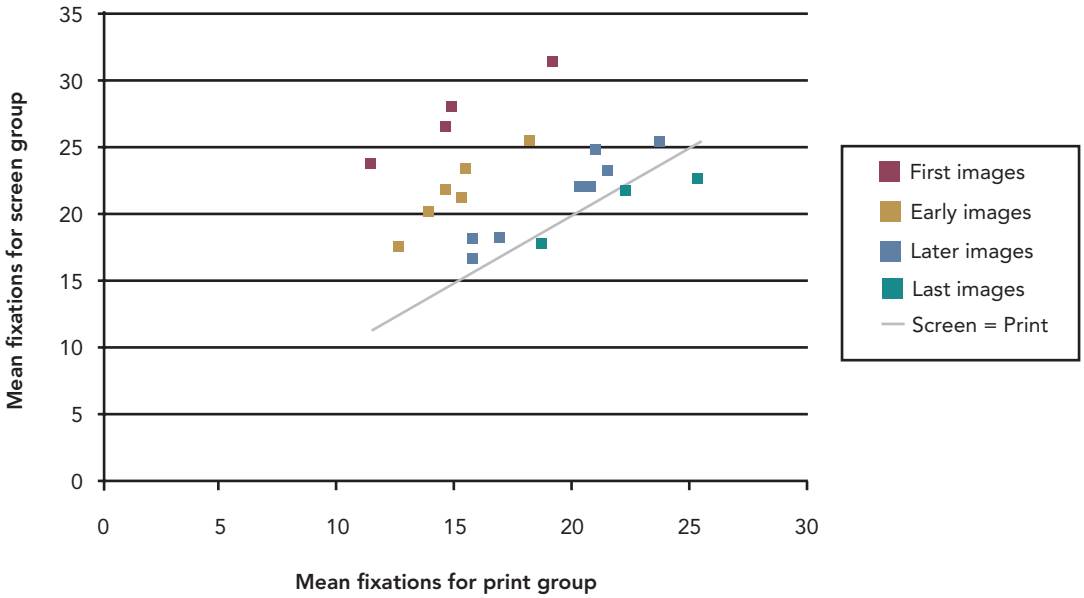

Figure 3-3. Mean fixation values for observers by group[1]

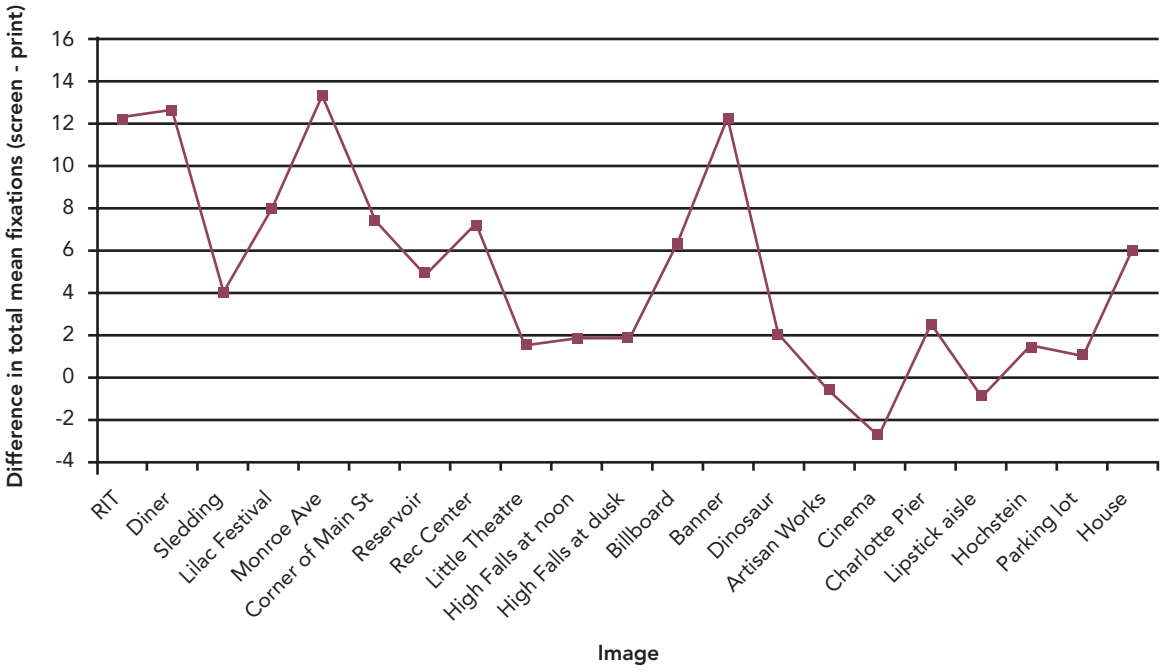

Figure 3-4. Difference between the mean number of fixations by observer group over the course of the photo book

1 - The first two, the fifth and the *Cellino and Barnes Banner* image are represented by red squares. The other images that occur early, the *Cellino and Barnes Billboard* image, and the final image are represented by gold squares, images that appear later in the book are represented by blue squares, and three of the final images in the book are represented by green squares.

A question of primary interest for this experiment was where observers were looking within the images. To get some understanding of where observers were looking, the images were divided into up to twelve logical image regions. Information on the regions is presented in Table F-1 (see Appendix F). The number of fixations in each region and which region was fixated first and last were recorded for each observer. In a variety of experimentation investigating where people look when they view pictorial images, ranging from Buswell to others in more recent years (Buswell, 1935; Zelinsky, Rao, Hayhoe & Ballard, 1996; Rayner, 1998), it has been determined that people tend to look first in the central area of the image and then move around in the image to view image details that provide information about the image as a whole. It is important to note that photographers and artists often compose their work so that the objects of key interest are centrally located. This would certainly influence the regions on which the observers tended to focus their attention, though it might not necessarily impact the region where they fixated first.

In the present work, it was found that observers did, in fact, tend to fixate most in the central regions of the image. Table 3-5 lists the most frequently fixated regions in the images. Figures 3-5 and 3-6 shows fixation frequency order for the image regions of the 21 pages of the photo book. It is evident from this data that the central regions attracted more attention, in general, than the top, bottom, side, or corner regions. The regions other than those in the central area of the image are shown in bold in Table 3-5. Regions other than central ones were fixated most often for only four images for the print group and five images for the screen group. Figures 3-5 and 3-6 show that a central region is fixated for more images from the first to the eighth most fixated regions for all observers. The one image that was something of an exception to this is the *Dinosaur Barbeque* scene (see Tables F-2 and F-3 in Appendix F). Observers tended to focus on the Dinosaur Barbeque building on the left side of the image, the bridges on the right, and the caption. Two of the screen observers, too, seemed particularly taken with the sky in this image, one fixating on it 7 times and one 16 times. Most of the other observers did not fixate on this region at all.

Table 3-5. Most fixated image regions by observer group[2]

Image	Print	Screen
RIT	Central buildings	Central buildings
Diner	Central diner	**Diner sign at top**
Sledding	Central trees	Central trees
Lilac Festival	Pretzels	**Signs on left**
Monroe Ave	Green	Green
Corner of Main St	Clock/flags	Clock/flags
Reservoir	Tower	Tower
Rec Center	Bald dude	Bald dude
Little Theatre	Guitar player	Central picture
High Falls at Noon	Falls	Central building
High Falls at Dusk	Central building	Central building
Billboard	Right guy	Windows
Banner	Central building	Central building
Dinosaur BBQ	**Left bridge**	**Sky**
Cinema Theater	Face	Face
Artisan Works	Central picture	Central picture
Charlotte Pier	**People on left**	Horizon
Lipstick Aisle	**Text**	**Text**
Hochstein	Choir	Choir
Parking Lot	**Oil spill**	**Oil spill**
House	Front of house	Front of house

2 - Regions that are not central to the image are in bold.

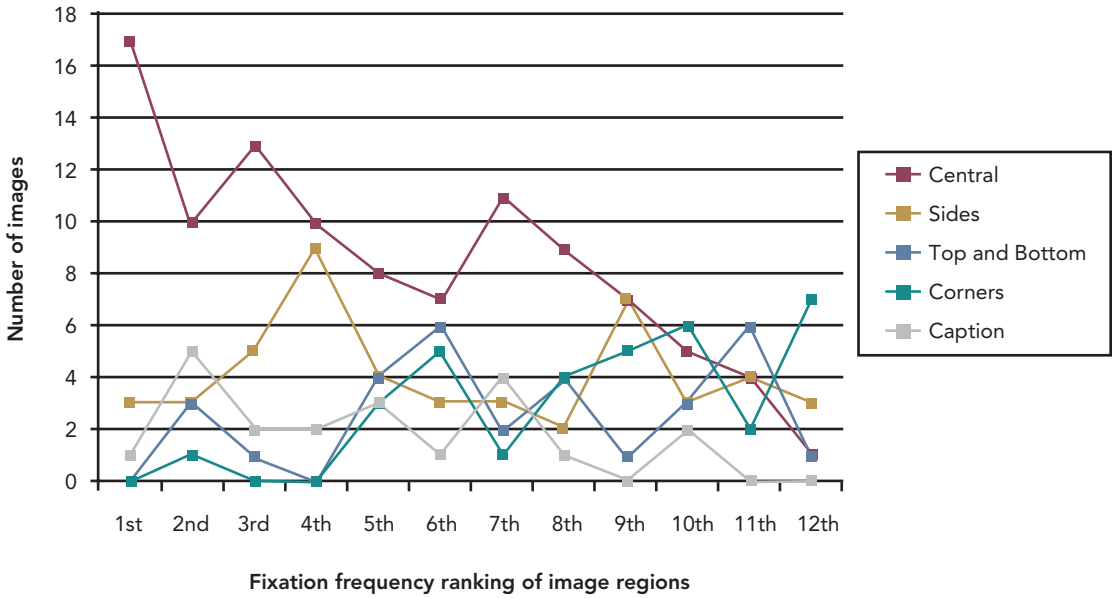

Figure 3-5. Fixation frequency rankings of image regions for the print group[3]

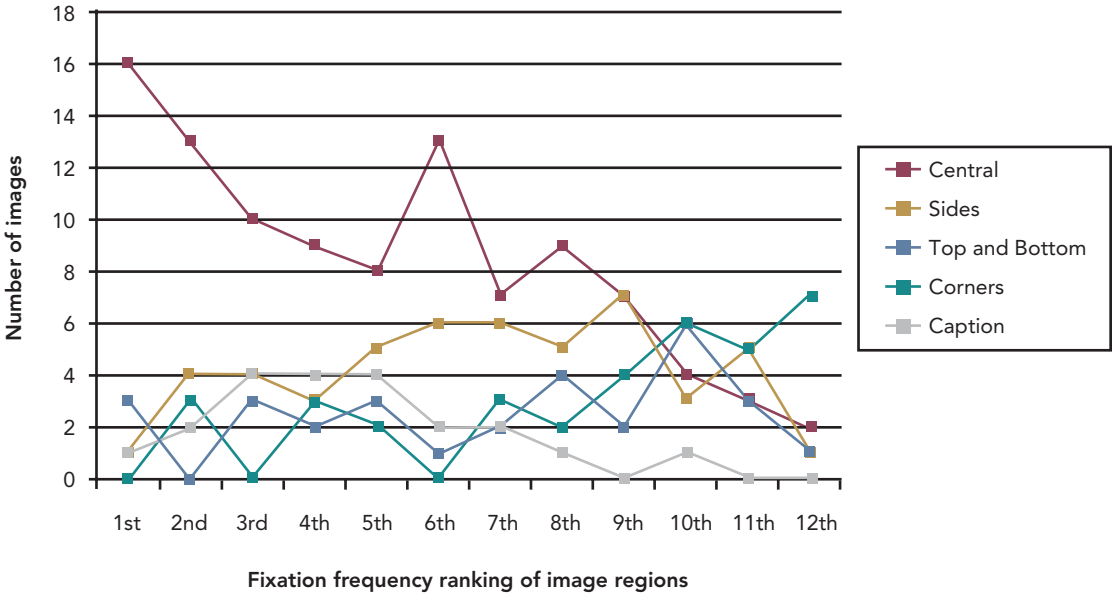

Figure 3-6. Fixation frequency rankings of image regions for the screen group[4]

3 - The number of the 21 images in the photo book that received each of the twelve rankings by image region. For example, a central region of 17 of the images was fixated first and a corner region of 7 images was fixated last (12th) for both the print and screen groups.

4 - The number of the 21 images in the photo book that received each of the twelve rankings by image region. For example, a central region of 17 of the images was fixated first and a corner region of 7 images was fixated last (12th) for both the print and screen groups.

In addition to fixating most frequently in the central areas of the images, this experiment also found that observers tended to fixate first somewhere in the center of each image, as shown in Table 3-6. The print group fixated first in areas outside of the center for only two of the 21 images, while the observers viewing the images on-screen had this occur for only one. They also tended to fixate in one of the central regions on their last fixation, though not quite as consistently as for their first fixation. The print group fixated in the central regions for all but two images and the screen group for all but four images.

Looking specifically at which regions were looked at first as shown in Table 3-6, observers most often fixated on the upper left central region, followed by the upper right central and center regions. The differences between the print and screen groups were subtle. The screen group tended to fixate first on the lower left central and top regions of the images more often than the print group. The print group tended to fixate first on the upper right central and left side more than the screen group. This may be because the lower central regions are a more comfortable viewing location when viewing the screen. In contrast, when looking at a printed book, the observer is viewing two images side-by-side. For this group of observers, the right side of the pages located on the left of a two-page spread and the left side of the images on the right would be located closer to the center of the viewing area. The observers in the print group fixated first on the left side of images that were on the right side of the two-page spread and generally fixated on the upper right central region for images located on the left. They also fixated last in the region on the right side for images located on the left side of the two-page spread.

The one notable exception to the tendency for observers to fixate first in the central regions of the images was the *Cellino and Barnes Future Advertising Plans* image, in which observers tended to look at the top of the image. This is also consistent with historical findings in that the flag waving around in the sky was not something one would expect to find in this image, and image-object incongruence tends to attract attention (Parkhurst, Law, & Niebur, 2002). The other exception was that the print group tended to look at the people on the left edge of the *Charlotte Pier* image on their first fixation. While this region was not in the center of the image, it is also not inconsistent with previous experimental results that people and horizon lines in images often attract attention.

Table 3-6. Average first and last fixations for image regions by observer group

Image	Print	Screen	Print	Screen
	First fixation	First fixation	Last fixation	Last fixation
RIT	Upper center, top corners	Center, left corners, top and bottom	Lower central and bottom corners	Sides
Diner	Upper center	Top and center	Upper center, bottom	Top corners and top
Sledding	Center, Upper center	Upper center, center	Center, upper center, left side	Upper center, center
Lilac Festival	Upper center	Upper center, top	Upper left center and right side	Upper left center into left side
Monroe Ave	Upper left center into left side, center	Upper and lower left center, left side	Lower left center	Upper left center
Corner of Main St	Center, upper right center	Center and top	Center	Center, lower left center, top
Reservoir	Upper right center	Upper right center	Upper right center	Upper right center
Rec Center	Lower right center	Lower right center	Upper left center, text	Upper left center, text
Little Theatre	Upper left center, left side	Left center, text	Upper right center	Upper center, top right corner
High Falls at Noon	Upper and lower left center	Upper left center, text	Lower left center	Upper left center
High Falls at Dusk	Upper left center, right side	Lower left center, upper left center	Upper left center	Upper left center, right side
Billboard	Center, upper right center	Center, lower center, upper right center	Text, lower center	Upper right center, center, right side
Banner	Top	Top	Top and center	Top and right side
Dinosaur BBQ	Center, right side	Upper left center, top	Right side, left side	Top, upper left center
Cinema Theater	Upper left center	Upper left center	Upper right center	Lower center, right side
Artisan Works	Center, lower right center	Center	Center, right side	Upper right corner
Charlotte Pier	Left edge	Bottom left center	Center	Bottom left center
Lipstick Aisle	Center, upper right center	Center, upper right center	Right side, text	Upper right center
Hochstein	Lower left center, upper left corner, left side	Lower left center	Lower right center	Lower right center
Parking Lot	Right side into top and into upper right center	Upper right center into right side and upper left center into center into lower right center	Upper right center into right side and left side	Upper right center into right side and left side
House	Center, upper left center	Center, text	Upper left center, right side	Upper left center

Yarbus, in his classic work examining the eye movements of observers looking at pictorial images, states that when faces are present observers often look at nothing else. He found that viewers are more likely to fixate on people than objects and on faces more than other areas of people, with eyes, then lips and noses, attracting the most attention of all (Yarbus, 1967). This is an interesting point to consider when looking at the results for Images 8 and 15 (the *Henrietta Recreation Center* and the *Cinema Theater Concert*, respectively). For both of these images, which contain relatively large faces, these face regions were fixated more than any other regions in the images, almost twice as often for the print group when viewing the face in the *Rec Center* image and for the screen group when viewing the face in the *Cinema Theater* image. Also, all of the observers in the print group fixated on the face in the *Rec Center* image first, and nearly all of the observers in the screen group did so as well. This image received the most consistent first fixations of all the images, with 11 of the 14 observers fixating on the face first. The *Cinema Theater* image was the next most consistent, with 9 of the 14 observers fixating on the face first.

Looking at other images that feature people, we see that the people in these images were also often fixated frequently. For example, in the *Lipstick Aisle* image, the woman in the image is fixated more often than any other region, on average; for the screen group, this was nearly twice as much as the next most fixated region. However, for the *Cellino and Barnes Billboard* image, while the print group fixated most on the picture of the man on the right, they fixated more on the caption than the man on the left. The screen group fixated more on the text on the billboard and on the caption than on either man. This may be because the image featured a billboard with pictures of humans rather than actual humans. (While this is also true of the *Henrietta Rec Center* image, this image *could* be considered more interesting than the *Billboard* image).

One region of particular interest in this experiment was the caption area. All viewers spent some time looking at the captions describing each image (see Tables 3-5 and 3-6). The text region was rarely the most fixated region, but it was never the least or even second least fixated region. Figure 3-7 shows the cumulative number of images in which the text fell in a given ranking among the image regions. Note that there is little difference between these curves for the print and screen groups of observers.

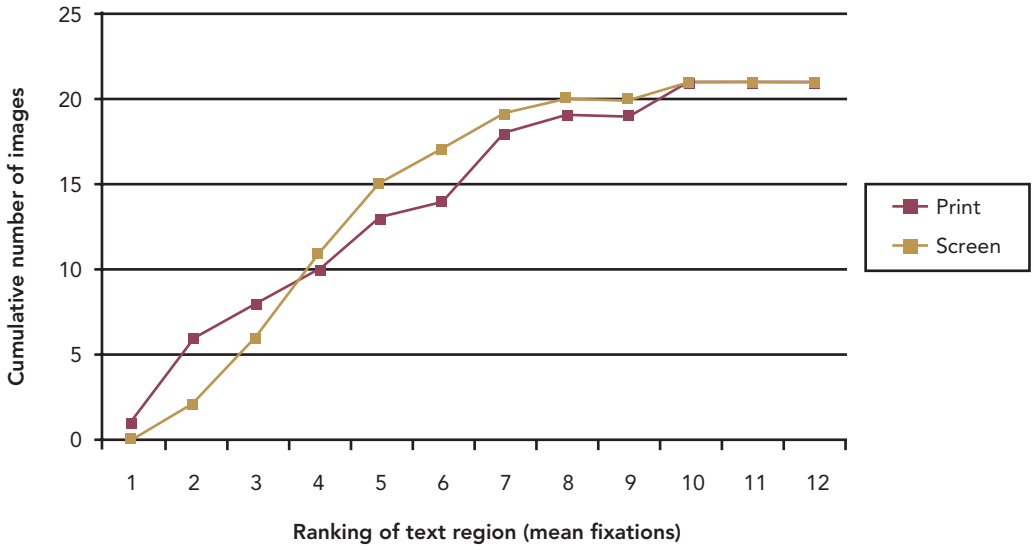

Figure 3-7. Cumulative number of photo book images with a rank for the text region in the ranking of image regions

The caption text, as noted earlier, was a region of particular interest for the *Dinosaur Barbeque* scene. Other images where the caption caught observers' attention include *Lipstick Aisle* (for which it was the most fixated region for both groups of observers), *Corner of Main Street*, the *House of Questionable Repute*, and the *Cellino and Barnes Billboard* images. It is possible that observers tended to spend more time with the text when the image content was less familiar. Another possibility for this phenomenon is the length of the caption. The observers spent the least time looking at the text for the *Charlotte Pier, Reservoir,* and *Lilac Festival* images, all of which had relatively short captions. There was a weak linear relationship between the number of fixations and the number of characters in the title as shown in Figure 3-8. However, the relationship for the screen group was a little stronger than for the print group. This data also indicated that it was possible that the print group did not read the entire caption for two of the images (the *Cellino and Barnes Billboard* image and the *Hochstein Music School* image).

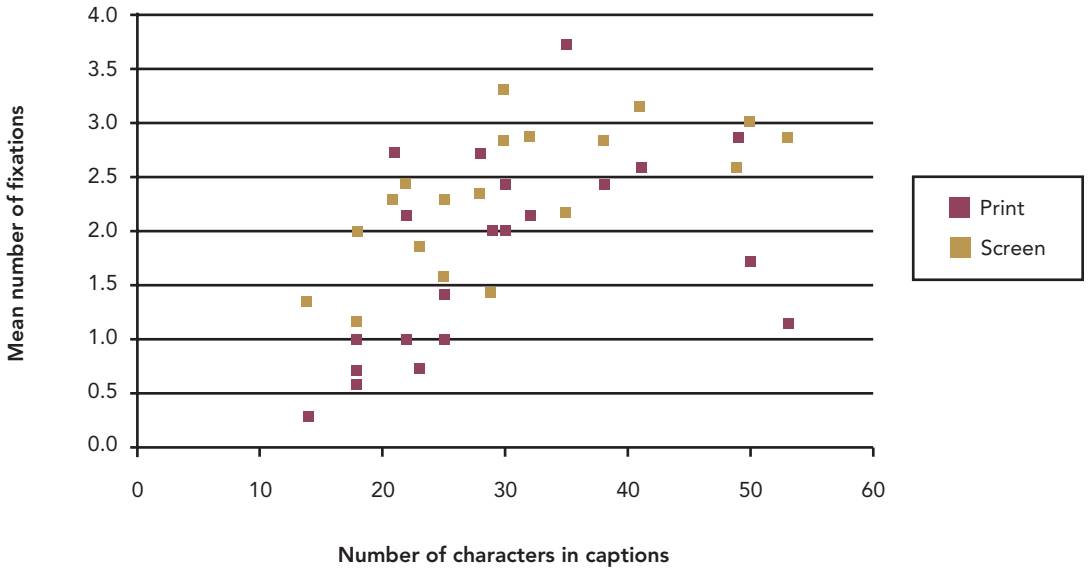

Figure 3-8. Mean number of fixations on the image captions by observer group

Generally, the observers fixated between one and three times on each caption. The captions had between three and nine words. Since observers can read up to three words per fixation, if a word is surrounded by small words such as 'and' and 'the', it is possible that observers were generally reading the entire caption (Rayner, 1998). By considering only the key words in the captions, there appears to be a relationship between the number of key words and the number of fixations for the screen group as shown in Figure 3-9. The caption for the RIT image falls well below the trend line (the gray square in Figure 3-9), possibly because the observers may have recognized the content and only needed to take a quick look at the caption for the information that they needed.

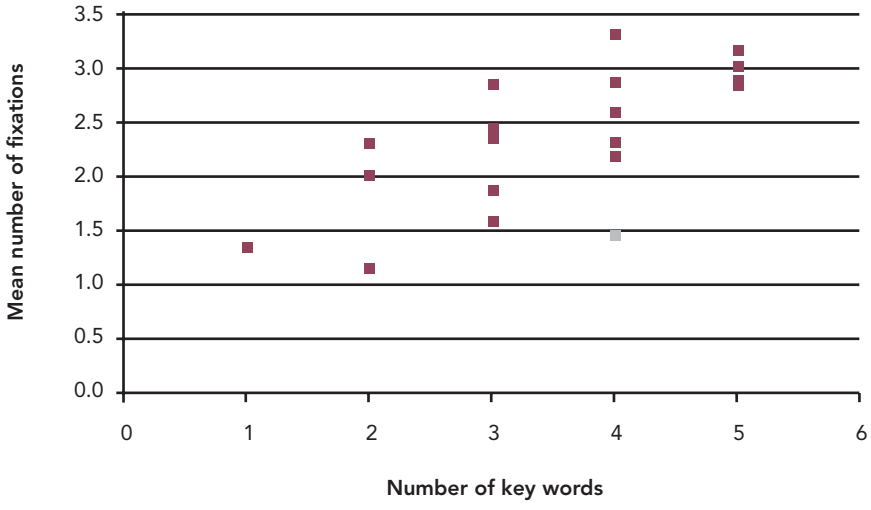

Figure 3-9. Mean number of fixations on the caption relative to the number of key words in that caption for the screen group

For the print group, this relationship was not as strong. However, if the images on the left side of the book are weighed more heavily, the relationship then becomes considerably better as shown in Figure 3-10. It appears that the print group might have fixated on each key word in the captions for the pictures on the left, but not for the images on the right. For the captions on the right, the print group had about half a fixation per key word. For the *Dinosaur Barbeque* image, which appeared on the left side of the book, they appear to have fixated twice on each key word on average..

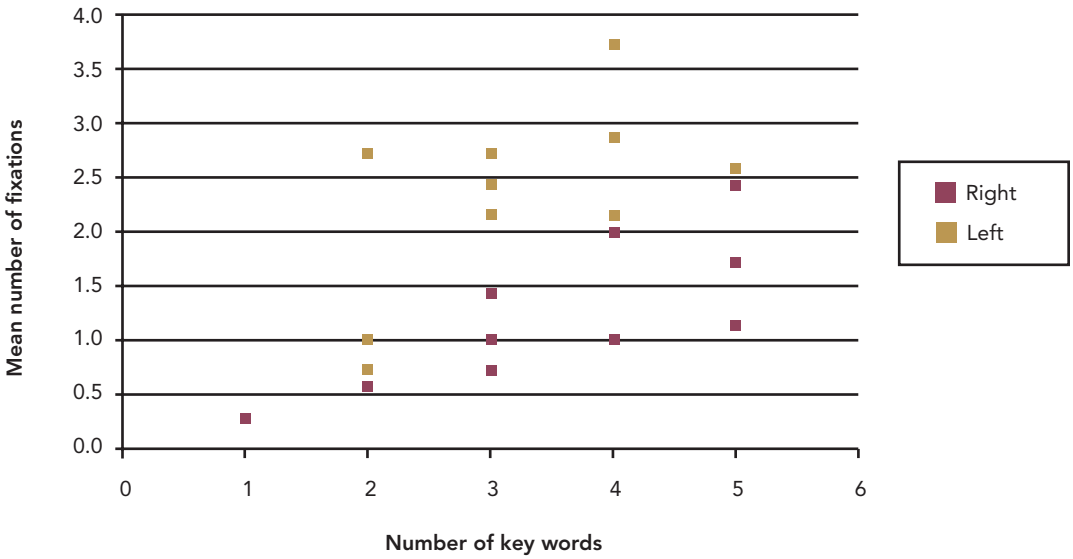

Figure 3-10. Mean number of fixations on the caption by the number of key words in that caption relative to image location within the book for the print group

The screen group tended to fixate more often on the captions than the print group, especially for images that were located on the right side of the printed book such as the *Cellino and Barnes Billboard, High Falls at Dusk, Monroe Avenue,* and *Hochstein Music School* images. The print group, however, fixated more often on the text for the *Lipstick Aisle* image than the screen group. This image was located on the left side of the book. The print group had twice as many fixations on the left image captions as they did on the right image captions, while the screen group had essentially an equal number of fixations on these two images when seen sequentially. It may be interesting to consider the *High Falls* images in this regard. The observers in the print group may have examined the caption for the *High Falls at Dusk* image less closely since they were viewing the two images side-by-side; information gained by reading the *High Falls at Noon* caption may have provided some of the information they needed for both images. The same could be true for the *Cellino and Barnes* images.

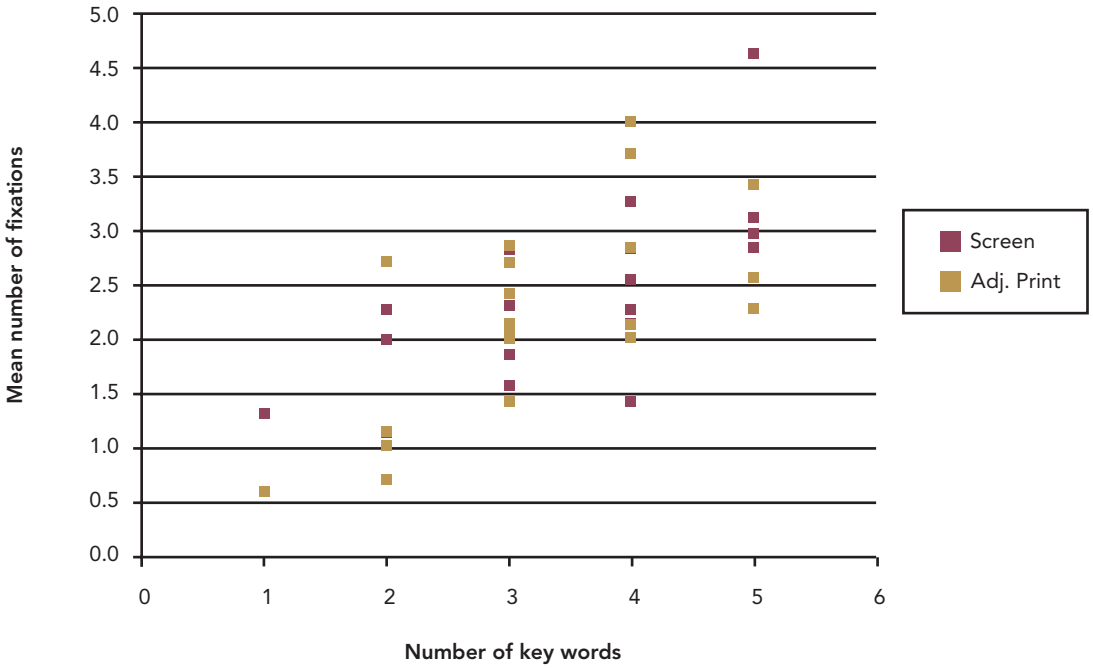

Figure 3-11. Mean number of fixations on the caption relative to the number of key words in that caption by observer group[5]

Another apparent difference between the two groups of observers was that the screen group fixated on the captions more frequently on their first fixations than their final fixations, while the opposite was true for the print group. The groups also differed in that they tended to fixate on captions for different images, although all observers tended to fixate on the caption for the *Henrietta Recreation Center* image on their final fixation. Fixation patterns for this image were the most consistent of any of the images.

One question asked of the observers in this experiment that had not been asked in earlier experimentation was to give a description of the image that they remembered the best. Looking at the images that they chose relative to the number of fixations made on those images, we see that observers tended to fixate about the average number of times or more on the image that they identified as the one that they remembered best, as shown in Figure 3-12.

5 - The print group's mean number of fixations for images on the left side of the book were divided in half.

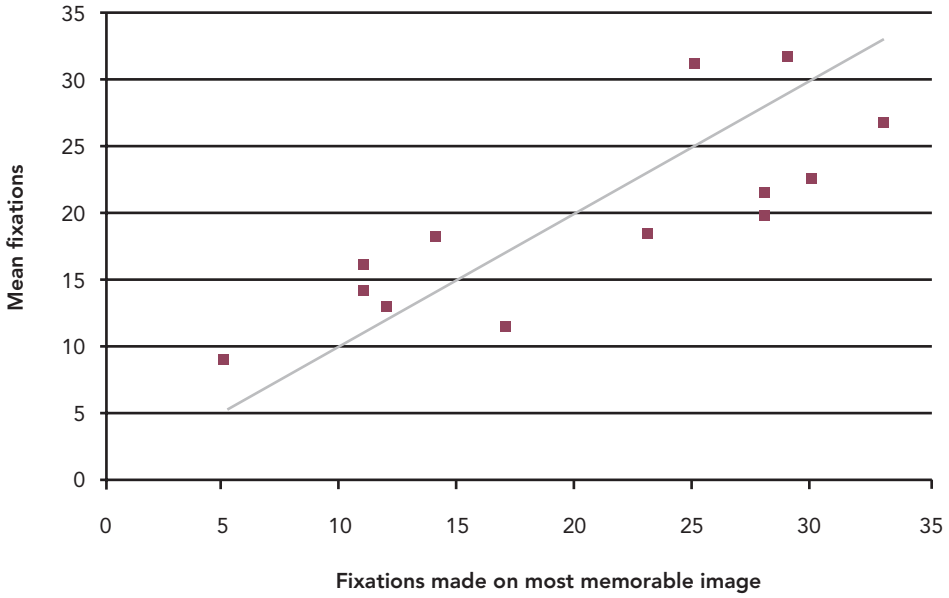

Figure 3-12. Mean number of fixations each observer had for all images relative to the number of fixations each observer had on the image they remembered the best[6]

Observers in the print group tended to switch between the images more often—on average twice per image—while the screen group almost never switched between images (see Table 3-7). Observers in the print group would often look briefly at the image on the right when turning a page before looking more closely at the image on the left. Also, observers in the print group tended to look back and forth between related images, such as the two images of High Falls.

Observers in the print group also tended to look away from the images more often than the screen group. Generally, they were looking at their fingers while turning pages or fixating between images as they moved their eyes from the left image to the right. The screen group tended to gaze at the edges of the computer when their eyes shifted from the images. While the eyes of observers in both groups at times drifted from the images, the fixations generally were in the neighborhood of the book or screen, although there was one screen viewer who spent some time examining the ceiling.

6 - Points above the line represent mean fixations that are higher than the fixation on the most memorable image, while those below are lower than that for the most memorable image.

Table 3-7. Total number of fixations off the images and mean changes per image by observer group

Image	Fixations off image		Mean changes per image	
	Print	Screen	Print	Screen
RIT	0	4	1	1
Diner	3	3	1.3	1
Sledding	1	1	1.9	1
Lilac Festival	3	2	1.4	1.1
Monroe Ave	3	2	2.0	1.1
Corner of Main St	3	1	1.3	1
Reservoir	1	1	1.4	1
Rec Center	0	2	1.3	1
Little Theatre	3	0	1.9	1
High Falls at Noon	2	0	4.7	1
High Falls at Dusk	1	0	4.6	1
Billboard	2	0	2.7	1
Banner	4	2	2.4	1
Dinosaur BBQ	1	1	1.7	1
Cinema Theater	4	1	2.1	1
Artisan Works	3	0	1.6	1
Charlotte Pier	1	0	1.7	1
Lipstick Aisle	4	0	1.9	1
Hochstein	8	0	2.0	1
Parking Lot	0	0	1.3	1
House	0	1	1.4	1

Conclusion

It is important to remember that a relatively small number of observers were included in this experiment. Different results may be obtained using a different group of observers. Drawing conclusions from this work must be done with a fair bit of caution. What we are really looking for is a better understanding of existing trends. In this experiment, it was found that both the observers viewing the print book and those viewing the screen version fixated most in the central regions of the images. They also had their first and last fixations in these central regions. An exception to this tendency was the *Cellino and Barnes Future Advertising Plans* image, in which the observers fixated first on the banner fluttering rather unexpectedly above the Rochester skyline. Of the 21 images in the book, the *Henrietta Rec Center* image had the most consistent viewing pattern, with the face of the bald man on the side of the video game being fixated first by 11 of the 14 observers and the text region often fixated last. The *Parking Lot, Diner, Lilac Festival* and *High Falls* images were the images most frequently identified as being the most memorable. This was not dependent on which medium was viewed, although both observers identifying the *High Falls* images as the most memorable had seen the print version of the book.

There were some important differences between the groups of observers. These include the following:

- The screen group tended to have more fixations per image for images early in the photo book than the print group.
- The print group tended to switch more between images than the screen group, generally starting with the right image after a page turn, moving to the left image, and then back to the right. The print group also switched between the images in both the *High Falls* and *Cellino and Barnes* image pairs more frequently than the screen group.
- The print group tended to have more fixations off image, looking at their fingers while turning pages and at the region between images on the two-page spread (exceptions to this were the first, last, and *Rec Center* images).
- The print group tended to have fewer fixations on images on the right side of the photo book than the screen group.

While photo books were used in this work to take advantage of the large sample sizes included in the research by Tsai and Cost and Frey and Rodriguez Adames, further work incorporating imagery with more of a blend of pictorial and textual content may prove enlightening with regard to the differences in how observers generally consume information from screens relative to the printed page.

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Appendix A: Descriptive Statistics and Chi-Square Tests of Association for Part I

Table A-1. Descriptive statistics

Statistic	N	Minimum	Maximum	Mean	Std. Deviation
Gender	39	0	1	.62	.493
Age	39	19	30	21.44	2.542
Age19_21	39	0	1	.67	.478
Age22_24	39	0	1	.23	.427
Age25_27	39	0	1	.05	.223
Age28_30	39	0	1	.05	.223
T(printed) in seconds	39	42	413	154.69	71.867
T(screen) in seconds	39	26	296	149.08	62.765
Prefer printed vs screen	39	0	1	.59	.498
Do you ever print?	39	0	1	.41	.498
Do parents print?	38	0	1	.84	.370
% of right image identification	39	.10	1.00	.7526	.22033
T(print) is higher?	39	0	1	.56	.502
Valid N (listwise)	38				

Table A-2A. Is preference for printed vs. screen associated with gender?

Prefer printed vs screen * Gender Crosstabulation		Gender		Total
		Female	Male	
Prefer printed vs screen	No	8	8	16
	Yes	7	16	23
Total		15	24	39

Table A-2B. Chi-square tests

Test	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	**1.526[a]**	**1**	**.217**	--	--
Continuity Correction[b]	.811	1	.368	--	--
Likelihood Ratio	1.522	1	.217	--	--
Fisher's Exact Test	--	--	--	.318	.184
Linear-by-Linear Association	1.487	1	.223	--	--
N of Valid Cases	39				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.15.

b. Computed only for a 2x2 table

Ho: Variables are independent

Ha: Variables are associated

Since p-value is over 0.05, we fail to reject the null hypothesis. Hence, based on these data, there is no statistical evidence of association between these variables.

Table A-3A. Is preference for printed vs. screen associated with time spent in printed/screen?

Prefer printed vs screen * T(print) is higher? Crosstabulation		T(print) is higher?		Total
		T(screen) is higher than T(printed)	T(printed) is higher than T(screen)	
Prefer printed vs screen	No	9	7	16
	Yes	8	15	23
Total		17	22	39

Table A-3B. Chi-square tests

Test	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	**1.768[a]**	**1**	**.184**	--	--
Continuity Correction[b]	1.003	1	.317	--	--
Likelihood Ratio	1.772	1	.183	--	--
Fisher's Exact Test	--	--	--	.209	.158
Linear-by-Linear Association	1.723	1	.189	--	--
N of Valid Cases	39				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.97.

b. Computed only for a 2x2 table

Ho: Variables are independent

Ha: Variables are associated

Since p-value is over 0.05, we fail to reject the null hypothesis. Hence, based on these data, there is no statistical evidence of association between these variables.

Appendix B: Tabular Data from Experiments for Part I

Table B-1. Participants' preferences for presentation medium

Participant	Preference	Comments
1	Print	More details
2	Screen	Easier to go through them
3	Print	More details
4	Print	More details. Vibrant colors
5	Screen	Easier to go through them
6	Screen	No comment
7	Print	Sharper and brighter colors
8	Screen	Printed ones looked highly saturated and blurry
9	Screen	Prints looked washed out. Could see more details on-screen
10	Print	Brighter images
11	Print	Shinier, crisper images
12	Screen	Brighter images
13	Screen	Brighter images
14	Print	Tangibles, can move them around, can look at them closer
15	Print	Finish is nicer. Colors more vibrant
16	Print	Like flipping through the pictures
17	Print	Ones on-screen lacked colors. Printed ones had more feeling/warmth on the colors
18	Print	Like to physically hold. Less distraction from screen applications. Less line sequence
19	Both	Really good quality
20	Print	Easier to go through them
21	Print	Shows how the exposure ends
22	Print	Don't seem to have as noticeable a color cast
23	Print	Cleaner, easier to go through
24	Print	Richer colors and more realistic images
25	Screen	Images are ready to be send out in a digital format
26	Print	Glossier. Like to be able to hold them
27	Print	Tangibles. Can move them around, can look at them closer. Better quality
28	Screen	Used to use the screen
29	Screen	More details
30	Screen	Colors more vibrant, more details
31	Print	Able to touch them
32	Print	More details. Vibrant colors
33	Screen	Get more for the whole picture
34	Screen	More details. Printed are too saturated
35	Screen	Easier to go through them
36	Screen	Sharper, more saturated images
37	Print	Glossier. More vibrant
38	Print	Like to be able to touch them
39	Print	Like to be able to hold them

Table B-2. Participants' preferences for printing or not

Participant	Ever print?	Comments
1	Yes	About 10%
2	No	-
3	No	-
4	Yes	Good to save it for good memories
5	No	Easier to organize them in computer
6	No	Just if wants to hang them up
7	Yes	Display purposes
8	Yes	To hang on a wall
9	Yes	Mainly for projects
10	No	-
11	No	Don't own a printer. Media consumption is on computer
12	Yes	To hang on wall. To share
13	No	No money
14	Yes	Scrapbooking
15	No	Don't really take pictures
16	No	No time
17	No	-
18	Yes	To make books. To fill frames as gifts
19	Yes	To put in an album
20	Yes	To give. To photo critiques
21	No	Too expensive
22	No	-
23	No	Don't know where and how much
24	No	No time
25	No	Only in book format. Loose photos are not fun
26	No	Too expensive. Most pictures not memorable enough
27	No	Too lazy
28	No	No money. No time
29	No	There's no need
30	Yes	Use labs @ RIT
31	No	No money. Online lot easier
32	Yes	Use Walgreens
33	Yes	To show friends
34	No	Likes to zoom in the images
35	Yes	To give
36	No	Too expensive
37	Yes	Assignment purposes
38	Yes	To hang on a wall
39	No	No money

Table B-3. Comments about parents' printing preferences

Participant	Parents Print?	Comments
1	Yes	Use film
2	Yes	Send images to print shop
3	Yes	Use friend's printer
4	Yes	-
5	Yes	-
6	Yes	Print at CVS pharmacy
7	Yes	Print at home. Use cheap paper
8	Yes	Send images to print shop
9	Yes	Print at home
10	Yes	-
11	Yes	Use iPhoto
12	No	Print at home
13	Yes	Send images to print shop
14	Yes	Send images to pharmacies
15	Yes	-
16	No	-
17	Yes	-
18	No	-
19	Yes	Print at CVS Pharmacy
20	Yes	Ask her daughter to print
21	Yes	Use Epson CX7400
22	Yes	-
23	Yes	Do not print after photography evolved to digital
24	No	-
25	Yes	-
26	Yes	-
27	No	Print at home. Use regular paper
28	Yes	Print at CVS pharmacy
29	Yes	Print at home
30	Yes	Send images to print shop
31	Yes	Send images to print shop
32	Yes	Send images to Walgreens
33	Yes	Print at home
34	Yes	Use an inkjet printer
35	Yes	-
36	Yes	Send images to print shop
37	Yes	Send images to print shop
38	Yes	Send images to Costco
39	No	-

Table B-4. Services used to print, edit, and share images

Participant	Service/Software
1	Photoshop/ Kodak EasyShare
2	Kodak/Bridge/Photoshop
3	CVS pharmacy
4	Kodak gallery / Photoshop
5	-
6	Kodak EasyShare/ CVS pharmacy
7	-
8	Wal-Mart/ Snapfish
9	RIT
10	-
11	iPhoto
12	-
13	-
14	Kodak EasyShare/Picasa
15	-
16	Kodak EasyShare/Target
17	Photoshop/Lightroom
18	Flickr/Facebook/Photoshop/Raw/Lightroom
19	Flickr/ Photobucket
20	Photoshop/ Photobucket account
21	-
22	-
23	Flickr
24	-
25	Online service/DPC. Facebook and Lulu
26	Flickr
27	Facebook
28	-
29	-
30	Flickr/Facebook/Photoshop/Raw/Lightroom
31	Facebook
32	-
33	-
34	-
35	Kodak EasyShare
36	Flickr
37	Flickr
38	Flickr
39	Facebook/Flickr/Shutterfly

Table B-5. Attention paid to pictures of others

Participant	Did you pay attention to pictures that were not yours?	Why or why not?
1	Yes	Recognized the area. Pretty good shots.
2	Yes	They were different
3	Yes	Wanted to find difference. Thought would be tested
4	Yes	Thought would be tested
5	Yes	Thought would be tested
6	Yes	Were more interesting
7	Yes	Curiosity
8	Yes	Different lighting
9	Yes	Interesting
10	Yes	Interesting
11	Yes	Visually interesting
12	Yes	Thought would be tested
13	Yes	Thought would be tested
`14	Yes	Interesting
15	Yes	Interesting. Never seen them before
16	Yes	Thought would be test
17	Yes	Wanted to see something different
18	Yes	Interesting. Never seen them before
19	Yes	They were different
20	Yes	Tried to figure out what they were
21	Yes	Thought would be tested
22	Yes	Thought would be tested
23	Yes	Interesting
24	Yes	Interesting
25	No	-
26	Yes	Thought would be tested
27	Yes	Thought would be tested
28	Yes	Thought would be tested
29	Yes	Haven't seen them before
30	Yes	They were different
31	Yes	Thought would be tested
32		-
33	Yes	Thought would be tested
34	Yes	Interesting
35	Yes	Different. Interesting
36	Yes	-
37	Yes	More interesting
38	Yes	Interesting
39	Yes	Interesting

Table B-6. Preference for getting pictures back

Participant	Would you like your pictures back?	Why?
1	Yes	Saves own money. Some of them are interesting
2	Yes	-
3	Yes	Interesting to find differences between screen and printed
4	No	Think it might help others with the experiment
5	Yes	-
6	Yes	-
7	Yes	For fun and sharing
8	No	Already had them
9	Yes	Somebody already paid for them
10	Yes	They're free
11	Yes	Should be fun
12	Yes	I shoot them
13	Yes	Nice to have them physical. Used to scrapbook when in high school
`14	Yes	Somebody already paid for them
15	No	I don't keep photos
16	Yes	Would be nice to have them
17	No	Don't really liked them
18	Yes	Personal property
19	Yes	To be use them in future works
20	No	I won't use them
21	Yes	To self critique
22	Yes	Because I never print
23	Yes	I feel better and happy to look at my own pictures
24	No	I won't use them
25	No	-
26	No	Not important images
27	Yes	To give to parents
28	Yes	I like them. Personal property
29	Yes	Personal property
30	No	I already have them
31	Yes	I will find something to do with them
32	Yes	-
33	Yes	Some of them are important
34	No	I don't need them
35	Yes	I liked them better printed
36	Yes	Just to have them
37	Yes	Love to have them printed

Appendix C: Images from the Photo Book

Aerial View of the RIT Campus

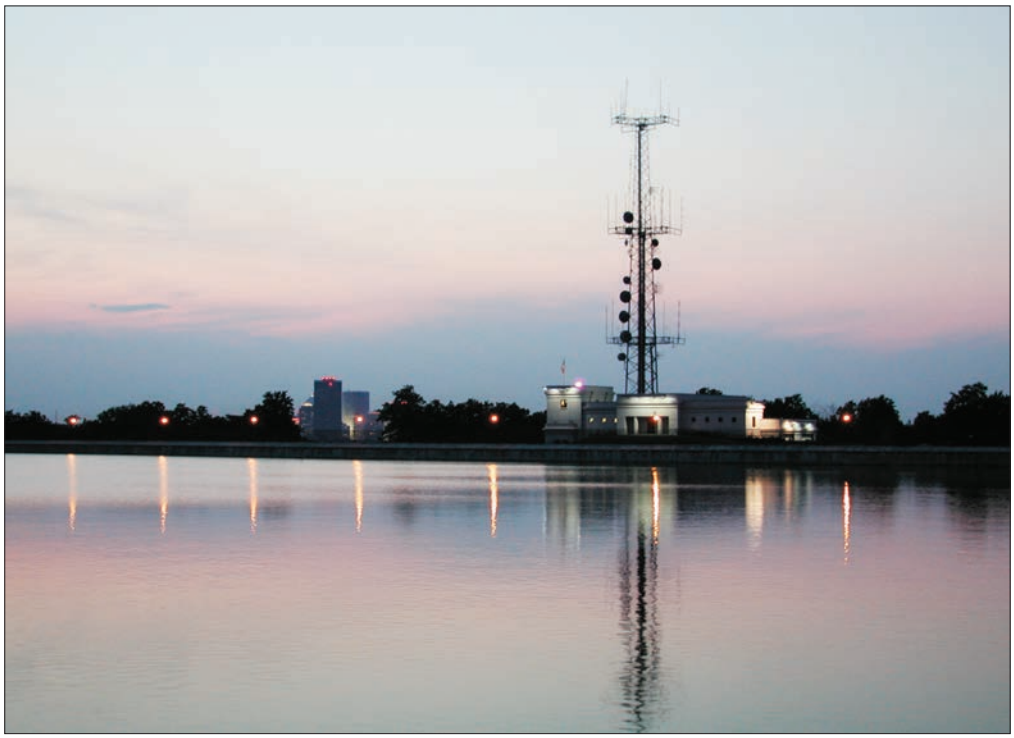
The Highland Diner

Sledding at Highland Park

The Lilac Festival

Show World, Monroe Avenue

The Corner of East Avenue and Main Street



Cobbs Hill Reservoir

Henrietta Town Recreation Center

The Little Theatre Cafe

The High Falls at Noon

The High Falls at Dusk

Cellino and Barnes, Your Injury Attorneys, Call 454-2020

Future Cellino and Barnes Rochester advertising plans

The Dinosaur Barbeque

Concert at the Artisan Works

Charlotte Pier

Lipstick Aisle in Pittsford Wegmans

Concert at the Hochstein School of Music and Dance

Henrietta Wal-Mart parking lot

House of Questionable Repute, Brighton

Appendix D: Test Questions for Parts II & III

1. Which of the fonts below is used in the photo book?

- `Rochester Landmarks` (Courier)
- Rochester Landmarks (Times New Roman)
- Rochester Landmarks (Papyrus)
- Rochester Landmarks (Garamond)
- Rochester Landmarks (Arial)

2. What are the weather conditions in the photo of the Highland Park Diner?

3. What are the people doing in the photo taken in Highland Park?

4. In the aerial view of RIT campus are the parking lots full or empty?

5. At what time of day was the picture of Cobb's Hill Reservoir taken?

6. How many people are in the picture of the Little Theatre Café?

7. Describe the hairstyle of the man pictured in the Henrietta Town Recreation Center?

8. What is the color of the car in the Henrietta Wal-Mart Parking lot?

9. How many bridges are visible in the picture of the Dinosaur Barbeque?

10. What color are the shirts people are wearing in the photo of the concert at the Hochstein School of Music and Dance?

11. The High Falls at Dawn, Noon, Dusk, and Night, which two pictures are not in the photo book?

12. Describe in detail the image in the photo book you remember the best.

13. You will now be shown ten images. Your task is to decide whether or not each appeared in the photo book. Please answer "Yes" if it did appear or "No" if it did not appear for each image.

Appendix E: Choice of Medium Preference Chi-Square Test for Part II

Table E-1. Choice of medium preference

Medium Shown	Medium Selected	Observed	Expected	Difference	Squared Difference	Squared Difference divided by Expected Frequency
Shown Book	Selected Book	29	23.74	5.26	27.67	1.17
Shown Book	Selected PDF	17	22.26	-5.26	27.67	1.24
Shown Electronic	Selected Book	3	8.26	-5.26	27.67	3.35
Shown Electronic	Selected PDF	13	7.74	5.26	27.67	3.57
						9.33

Degrees of Freedom = (2-1)(2-1) = 1

$\chi^2 = 9.33 > \chi^2.05 = 3.841$

Appendix F: Tabular Data from Experiments for Part III

Table F-1. Key regions of the photos included in the book

Image	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10	Region 11	Region 12
RIT	Text	Central bldgs	Athletic field	Track	Parking lot	North parking	Ctr west bldgs	South bldgs	River	West bldgs	Upper left	Upper right
Diner	Text	Sign	Central diner	Man	Reflected sign	Red re-flection	Spot light	Center reflections	Diner left	Lower right	Reflected left	Upper right
Sledding	Text	Central people	Central trees	People on left	People on right	Tree trunk	Horiz. branches	Trees on left	Bldg	Sky	Red ctr person	
Lilac Festival	Text	Pretzels	Coca-Cola	Waffles - center	Waffles - right	Signs on left	Central people	People on left	Right booth	Lit booth	Sky	Path
Monroe Ave	Text	Green	Orange	Car	Sign	Bldg on right	Road	Right green	Chimney	Windows	Trees	Arch
Corner of Main St	Text	Door	Clock/flag	Above door	Tower	Windows top right	Windows top left	Windows lower right	Cars	Bldg on right	Traffic light	Light post/ban-ners
Reservoir	Text	Tower	Bldgs & trees on left	Bldgs & trees on right	Right blue/pink sky	Left blue/ pink sky	Light re-flections	Tower reflection	Water right	Water left	Right white sky	Left white sky
Rec Center	Text	Bald man	Other man	Boy 1	Boy 2	Boy 3	Jeans	Lower right	Remain-der of lit area	Upper right	Bottom	Coin cup
Little Theatre	Text	Guitar player	Bass player	Trumpet player	Central/ left pic-ture	Central/ right picture	Lower right	Upper left	Upper right	Lower left		
High Falls at noon	Text	Falls	Rainbow	Central bldg	Bldgs on right	Bldgs on left	Water	Grass	Dark area on left	Sky		
High Falls at dusk	Text	Falls	Central bldg	Bldgs on right	Bldgs on left	Water	Orange area on left	Blue sky	White sky	Lit cliff	Lower bldgs & grass	
Billboard	Text	Picture of man	Picture of man	Names	Number	Sky	Trees	Bldg	Windows	Bottom of sign		
Banner	Text	Flag	Bldg on left	Central bldg	Bldg on right	Trees	Sky/ clouds	River/ bridge	Grass	Tower	Antenna	Kodak
Dinosaur BBQ	Text	Dinosaur	Old bridge right	Old bridge left	New bridge	Center bldg	Tower	Cars	River left	River center	River right	Sky
Cinema	Text	Face	White	Orange screen	Orange curtain	Right curtain	Band	Audience	Right speaker	Door		
Artisan Works	Text	Man/red picture	Blue picture	Primary picture	Guitar	Blue pics/ angel	White shirts	Picture	Keyboard-ist	Central right	Lower left dark corner	Light/ green sign
Charlotte Pier	Text	Central people	People on right	People on left	People on ctr-L	Clouds on right	Clouds on left	Sky	Shadows/ pier	Horizon		

Table F-1. Key regions of the photos included in the book (continued)

Image	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10	Region 11	Region 12
Lipstick aisle	Text	Woman	Girl	White light	Sign	Lipstick in center	Lipstick on left	Ceiling	Floor	Lower price		
Hochstein	Text	White shirts	Stage	Sound deflectors	Windows	Balcony	Ceiling	Upper left sound	Lower left sound	Right sound	Conduc-tor	Ctr/mic
Parking lot	Text	Yellow stripe	Oil	Red car	Wheel	Gray pavement						
House	Text	Bunny	Front	Side	Taillights	Sky	Dark area at bottom	Door	Lower left window			

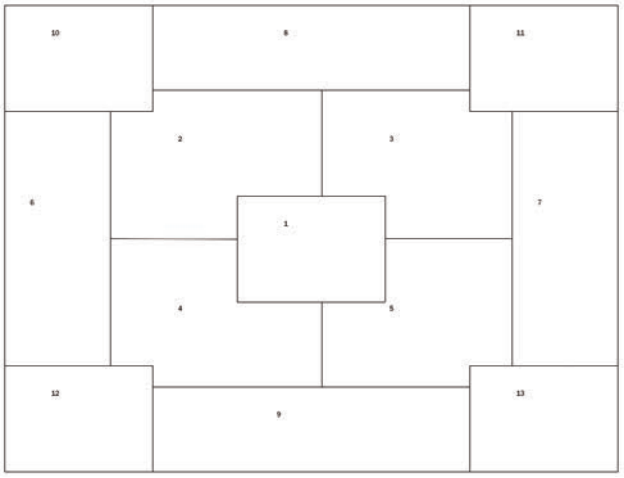


Figure F-1. General regions of the images in the photo book

Table F-2. Regions of key interest for the observers viewing the printed photo book[7]

Image	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
RIT	**2**	text	8	7	12	11	**3**	**5**	6	**1**	9	10
Diner	**3**	**4, 5**	**2**	text	8	7	**1**	9	6	10	13	11
Sledding	**1,2**	**2,3**	**4**	text	7	**5**	8	6	6	7	**1**	13
Lilac Festival	**2,3**	7	6	**1**	**2**	**3**	8	**2,6**	11	text	8	12
Monroe Ave	**2**	**1**	7	6	**4**	**2,6**	text	**4**	**5**	13	**3**	10
Corner of Main St	**1**	text	**3**	**2**	9	**4**	7	8	**1**	7	**5**	6
Reservoir	**3**	**3**	**4**	**2**	**4**	12	**5**	text	9	10	11	13
Rec Center	**5**	text	**2**	6	**2**	**1**	6	13	**3**	**4**	8	9
Little Theatre	**2**	6	**3,5**	**3**	**2,4**	12	text	10	11	13		
High Falls at noon	**4**	**2**	7	**5**	text	7	12	**1**	6	13	8	
High Falls at dusk	**2**	**4**	6	7	12	**2,3**	text	**1**	7	8		
Billboard	**3**	text	**4,5**	**1**	6	9	**4,5**	**2,3**	7			
Banner	**1**	8	7	6	8	text	**5**	**5**	13	**2**	**5**	
Dinosaur	6	7	text	7	12	13	**2,6**	9	**2**	7	8	**1**
Cinema	**2**	9	**4,5**	**3**	text	7	6	6	**2,4**	13	7	
Artisan Works	**1**	text	**5**	**3**	7	12	**4**	**2**	11	8	6	7
Charlotte Pier	6	**4**	**1**	7	**2**	9	**5**	8	**3**	text		
Lipstick aisle	text	**3**	**1**	7	**4**	**2,4**	**2**	11	12	9	7	6
Hochstein	**4**	**5**	**4,5**	6	text	8	**2**	10	7	**5**	9	11
Parking lot	6	**3,7**	text	**1,2,5**	7,9	8,11	**2**					
House	**2**	9,12	**1**	**5**	**3**	8	text	**5**	**3**	**4**	7	

7 - Regions are listed from the most to the least fixated for each of the images. Central regions are in bold.

Table F-3. Regions of key interest for the observers viewing the electronic version of the photo book[8]

Image	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
RIT	**2**	11	6	12	**3**	**1**	8	text	**5**	9	7	10
Diner	8	**3**	**1**	**2**	11	text	7	**4, 5**	6	10	9	13
Sledding	**1,2**	**2,3**	**4**	7	text	7	8	**1**	6	6	**5**	13
Lilac Festival	**2**,6	6	**2**	8	7	**2,3**	**1**	8	**3**	text	11	12
Monroe Ave	**2**	7	**1**	**4**	**4**	text	6	**2**,6	**3**	13	10	**5**
Corner of Main St	**1**	text	**2**	**4**	8	**3**	7	**1**	6	9	7	**5**
Reservoir	**3**	**3**	**4**	10	text	**2**	**4**	**5**	12	11	9	13
Rec Center	**5**	**1**	text	**2**	6	**2**	13	**3**	8	**4**	6	9
Little Theatre	**3**	11	**2**	**2,4**	6	**3,5**	text	10	12	13		
High Falls at noon	**2**	**4**	8	7	text	6	7	12	**5**	**1**	13	
High Falls at dusk	**2**	**4**	**2,3**	7	text	6	12	**1**	7	8		
Billboard	9	**1**	**2,3**	text	6	**3**	**4,5**	**4,5**	7	8		
Banner	**1**	7	8	text	**2**	**5**	6	8	**5**	**5**	13	
Dinosaur	8	**2**	6	text	7	**1**	**2**,6	7	12	9	7	13
Cinema	**2**	text	9	**3**	**4,5**	7	13	6	**2,4**	6	7	
Artisan Works	**1**	11	7	text	**2**	**4**	**3**	8	6	**5**	12	7
Charlotte Pier	**1**	**4**	6	8	**2**	**3**	text	7	**5**			
Lipstick aisle	text	**3**	**4**	11	**1**	7	**2,4**	**2**	12	7	9	
Hochstein	**4**	**5**	text	**4,5**	8	**2**	6	7	9	10	**5**	11
Parking lot	6	**3**,7	text	**1,2,5**	8,11	7,9						
House	**2**	**1**	text	**3**	**5**	**4**	**5**	8	7	9,12	**3**	

8 - Regions are listed from the most to least fixated for each image. Central regions are in bold.

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